1239344

CLASS 1 MODIFICATIONS TO HANFORD FACILITY RCRA PERMIT

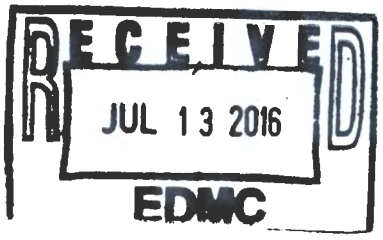
SECTION 1 OF 7

1239344

ENCLOSURE

CLASS 1 MODIFICATIONS FOR QUARTER ENDING June 30, 2016
Ms. S. L. Dahl-Crumpler, Ecology

Consisting of 3377 pages,
including this cover page



A-6005-441 (REV 2)

Attached to: 1239343

Hanford Facility RCRA Permit Modification Notification Forms

Standard and General Conditions

Index

Page 2 of 3 Unit Status Table
Page 3 of 3 Page 46

Submitted by Co-Operator: 6/13/16 Date

Reviewed by RL Program Office: 6/14/16 Date

Hanford Facility RCRA Permit Modification Notification Form

Unit:	Permit Part
N/A	Standard and General Conditions

Description of Modification:
Unit Status Table (page 12, first row under "Unit")

Changes are needed to convey the removal of 331-C requirements from the Permit. Language is added to show that 331-C requirements are being retired from Permit Revision 8c and to identify the date of closure (July 22, 2011 (11-NWP-076).

Chapter 3.0, Tables 3.1 and 3.3	Class 1	Class [1]1	Class 2	Class 3
Please mark the Modification Class:		X		

Per WAC 173-303-830(4)(d), the Permittee requests that this modification be reviewed and approved as a Class 1-prime.

The Permittees have completed closure activities following the approved Closure Plan (Addendum H). Ecology accepted the Independent Qualified Registered Professional Engineer certification of Clean Closure on July 22, 2011 (11-NWP-076).

This modification is the final step in removing the 331-C Storage Unit from the Permit. A public comment period was held from May 1 to October 22, 2012. No outstanding issues or comments were received.

The 331-C storage unit RCRA closure was integrated with the 300 Area CERCLA removal action, which was accomplished by demolition of the building, to include the floor slab in any below grade structures (e.g., containment sumps), in August 2013. The 331-C Storage unit was demolished via CERCLA removal in accordance with the Removal Action Work Plan for The River Corridor General Decommissioning Activities, DOE/RL-2010-34, Rev. 0.

Modification Approved: ☒ Yes ☐ No (state reason for denial)	Reviewed by Ecology:
Reason for denial:	S. L. Dahl-Crumpler 6/28/16 Date

[1] Class 1 modifications requiring prior Agency approval.

[2] If the proposed modification does not match any modification listed in WAC 173-303-830 Appendix I, then the proposed modification should automatically be given a Class 3 status. This status may be maintained by the Department of Ecology, or down graded to a Class [1]1, if appropriate.

Hanford Facility RCRA Permit Modification Notification Form	
Unit: **N/A**	Permit Part **Standard and General Conditions**

Description of Modification:
Page 46, line 36

Changes are needed to convey the removal of 331-C requirements from the Permit.

WAC 173-303-830 Modification Class [1] [2]	Class 1	Class [1]1	Class 2	Class 3
Please mark the Modification Class:		X		

Per WAC 173-303-830(4)(d), the Permittee requests that this modification be reviewed and approved as a Class 1-prime.

The Permittees have completed closure activities following the approved Closure Plan (Addendum H). Ecology accepted the Independent Qualified Registered Professional Engineer certification of Clean Closure on July 22, 2011 (11-NWP-076).

This modification is the final step in removing the 331-C Storage Unit from the Permit. A public comment period was held from May 1 to October 22, 2012. No outstanding issues or comments were received.

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Modification Approved: [X] Yes [ ] No (state reason for denial)	Reviewed by Ecology:
Reason for denial:	S. L. Dahl-Crumpler 6/29/16 Date

[1] Class 1 modifications requiring prior Agency approval.

[2] If the proposed modification does not match any modification listed in WAC 173-303-830 Appendix I, then the proposed modification should automatically be given a Class 3 status. This status may be maintained by the Department of Ecology, or down graded to a Class 1, if appropriate.

Remove and Replace the Following Pages:

Remove and replace the following pages:

- Conditions.12
- Conditions.46.

UNIT	Permit Revision		Comments/History
	Incorporated	Retired	
331-C Storage Unit	Rev. 8B	Rev. 8C	Closed, 7/22/11
400 Area Waste Management Unit	Rev. 8C		
PART IV, CORRECTIVE ACTION			
100-NR-1 Operable Unit	Rev. 6		
100-NR-2 Operable Unit	Rev. 6	Rev. 8C	Retired, 9/30/09
PART V, UNDERGOING CLOSURE UNITS			
100-D Ponds	Rev. 5	Rev. 6	Closed, 8/9/99
105 DR Large Sodium Fire Facility	Rev. 2	Rev. 6	Closed, 7/1/04
1301-N Liquid Waste Disposal Facility	Rev. 5		
1324-N Surface Impoundment	Rev. 5		
1324-NA Percolation Pond	Rev. 5		
1325-N Liquid Waste Disposal Facility	Rev. 5		
200 West Area Ash Pit Demo Site	Rev. 1	Rev. 6	Closed, 11/28/95
2101-M Pond	Rev. 1	Rev. 6	Closed, 11/28/95
216-B-3 Expansion Ponds	Rev. 1	Rev. 6	Closed, 7/31/95
218-E-8 Borrow Demolition Site	Rev. 1	Rev. 6	Closed, 11/28/95
2727-S Storage Facility	Rev. 0	Rev. 6	Closed, 7/31/95
300 Area Solvent Evaporator	Rev. 0	Rev. 6	Closed, 7/31/95
300 Area Waste Acid Treatment System	Rev. 6	Rev. 8B	Closed, 1/21/05
303-K Storage Facility	Rev. 4	Rev. 6	Closed, 7/22/02
304 Concretion Facility	Rev. 2	Rev. 6	Closed, 1/21/96
311 Tanks (includes 300 Area WATS)	Rev. 6	Rev. 7	Closed, 5/20/02
3718-F Alkali Metal Treatment /Storage	Rev. 3	Rev. 6	Closed, 8/4/98
4843 Alkali Metal Storage Facility	Rev. 3	Rev. 6	Closed, 4/14/97
Hanford Patrol Academy Demo Site	Rev. 2	Rev. 6	Closed, 11/28/95
Simulated High Level Waste Slurry	Rev. 1	Rev. 6	Closed, 9/6/95
PFP Treatment Unit (HA-20MB)	Rev. 8B	Rev. 8B	Closed, 2/8/05
241-Z Treatment and Storage Tanks	Rev. 8B	Rev. 8B	Closed, 2/22/07
303-M Oxide Facility	Rev. 8B	Rev. 8B	Closed, 6/15/06
224-T Transuranic Waste Storage and Assay Facility	Rev. 8C	Rev. 8C	Closed, 11/12/08

II.Z.1.b The proposed method of treatment, storage or disposal is that practicable method currently available to the Permittee, which minimizes the present and future threat to human health and the environment.

II.Z.2 The Permittee will maintain each such certification of waste minimization in the operating record as required by Permit Condition II.I.1.

II.AA Air Emission Standards for Process Vents

The Permittees will comply with applicable requirements of WAC 173-303-690 for process vents associated with Part III units performing specific separations processes unless exempted by WAC 173-303-690(1)(d). Threshold limits applied to process vents potentially requiring emission controls subject to WAC 173-303-690 are evaluated based on the summation of applicable emission sources for the entire Hanford Facility. When the summed emissions fall below threshold limits in 40 CFR 264.1032(a)(1), no emission control devices are required. If threshold limits in 40 CFR 264.1032(a)(1) are predicted to be exceeded, the Permittees will notify Ecology to determine the appropriate course of action. Unit-specific information is contained in Part III of the Permit for applicable units.

II.BB Air Emission Standards for Equipment Leaks

The Permittees will comply with applicable requirements of WAC 173-303-691 for certain equipment leaks associated with Part III units unless exempted by WAC 173-303-691(1)(e) or (f). Air emission standards apply to equipment that contacts or contains hazardous wastes with organic concentrations of at least 10 percent by weight. Unit-specific information is contained in Part III of the Permit for applicable units.

II.CC Air Emission Standards for Tanks, Surface Impoundments, and Containers

The Permittees shall comply with applicable requirements of WAC 173-303-692 for containers, tanks, and surface impoundment areas associated with Part III units unless exempted by WAC 173-303-692(1)(b). Unit-specific information is contained in Part III of the Permit for applicable units.

PART III UNIT-SPECIFIC CONDITIONS FOR FINAL STATUS OPERATIONS

Operating Unit 2, PUREX Storage Tunnels

Operating Unit 3, Liquid Effluent Retention Facility and 200 Area Effluent Treatment Facility

Operating Unit 4, 242-A Evaporator

Operating Unit 5, 325 Hazardous Waste Treatment Units

Operating Unit 10, Waste Treatment and Immobilization Plant

Operating Unit 11, Integrated Disposal Facility

~~Operating Unit 15, 331 C Storage Unit~~

Operating Unit 16, 400 Area Waste Management Unit

PART IV UNIT SPECIFIC CONDITIONS FOR CORRECTIVE ACTION

Corrective Action Unit 1, 100-NR-1

PART V UNIT-SPECIFIC CONDITIONS FOR UNITS UNDERGOING CLOSURE

Closure Unit 1, 1325-N Liquid Waste Disposal Facility

Hanford Facility RCRA Permit Modification Notification Forms

Attachment 3 (Security)

Index

Page 2 of 2 Section 3.1.3

Submitted by Co-Operator: _____ 6/13/16
Date

Reviewed by RL Program Office: _____ 6/14/16
Date

Hanford Facility RCRA Permit Modification Notification Form	
Unit: **N/A**	Permit Part **Attachment 3**

Description of Modification:
Section 3.1.3 (page 3.6)

Changes are needed to convey the removal of 331-C requirements from the Permit.

Chapter 3.0, Tables 3.1 and 3.3	Class 1	Class [1]1	Class 2	Class 3
Please mark the Modification Class:		X		

Per WAC 173-303-830(4)(d), the Permittee requests that this modification be reviewed and approved as a Class 1-prime.

The Permittees have completed closure activities following the approved Closure Plan (Addendum H). Ecology accepted the Independent Qualified Registered Professional Engineer certification of Clean Closure on July 22, 2011 (11-NWP-076).

This modification is the final step in removing the 331-C Storage Unit from the Permit. A public comment period was held from May 1 to October 22, 2012. No outstanding issues or comments were received.

The 331-C storage unit RCRA closure was integrated with the 300 Area CERCLA removal action, which was accomplished by demolition of the building, to include the floor slab in any below grade structures (e.g., containment sumps), in August 2013. The 331-C Storage unit was demolished via CERCLA removal in accordance with the Removal Action Work Plan for The River Corridor General Decommissioning Activities, DOE/RL-2010-34, Rev. 0.

Modification Approved: ☒ Yes ☐ No (state reason for denial) Reason for denial:	Reviewed by Ecology: S. L. Dahl-Crumpler — Date: 6/28/16

[1] Class 1 modifications requiring prior Agency approval.

[2] If the proposed modification does not match any modification listed in WAC 173-303-830 Appendix I, then the proposed modification should automatically be given a Class 3 status. This status may be maintained by the Department of Ecology, or down graded to a Class [1], if appropriate.

Remove and Replace the Following Pages:

Remove and replace Attachment 3, page 3.6.

3.1.3 Natural or Artificial Barriers

The majority of TSD units and unit groups are located within the controlled access area of the Hanford Site. Vehicular access to roads leading to the controlled area is through 24-hour controlled access points at the Wye, Yakima, and Rattlesnake barricades. The barricades are posted with restrictive signage to meet security requirements at the Hanford Facility level for the 100 Areas, 200 Areas, and 600 Area TSD units and unit groups. Perimeter fences, restrictive signage, and random protective force patrols are used to control access to the 300 Area and 400 Area. Additional means to bar entry or control access (e.g., fences, locked entry doors) are discussed, as necessary, ~~for 331 C Storage Unit,~~ the 325 Hazardous Waste Management Unit~~,~~ and the 400 Area Waste Management Unit in their unit specific Permit conditions.

The Hanford Facility level security systems are also in place to satisfy the security requirements of WAC 173-303-310(2)(c), (artificial or natural barriers).

Hanford Facility RCRA Permit Modification Notification Forms

Attachment 9 (Permit Applicability Matrix)

Index

Page 2 of 2 Page 9.11

Submitted by Co-Operator: _____ 6/13/16
Date

Reviewed by RL Program Office: _____ 6/14/16
Date

Hanford Facility RCRA Permit Modification Notification Form	
Unit: **N/A**	Permit Part **Attachment 9**

Description of Modification:
Page 9.11

Changes are needed to convey the removal of 331-C requirements from the Permit.

Chapter 3.0, Tables 3.1 and 3.3	Class 1	Class [1]1	Class 2	Class 3
Please mark the Modification Class:		X		

Per WAC 173-303-830(4)(d), the Permittee requests that this modification be reviewed and approved as a Class 1-prime.

The Permittees have completed closure activities following the approved Closure Plan (Addendum H). Ecology accepted the Independent Qualified Registered Professional Engineer certification of Clean Closure on July 22, 2011 (11-NWP-076).

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Modification Approved: ☒ Yes ☐ No (state reason for denial)	Reviewed by Ecology:
Reason for denial:	S. L. Dahl-Crumpler — Date 6/28/16

[1] Class 1 modifications requiring prior Agency approval.

[2] If the proposed modification does not match any modification listed in WAC 173-303-830 Appendix I, then the proposed modification should automatically be given a Class 3 status. This status may be maintained by the Department of Ecology, or down graded to a Class [1], if appropriate.

Remove and Replace the Following Pages:

Remove and replace Attachment 9, page 9.11.

PART III									
CONDITION		CATEGORY							QUALIFIERS
PART	TITLE	A	B	C	D	E	F	G	
III.	UNIT SPECIFIC CONDITIONS FOR FINAL STATUS OPERATIONS								
III.2	PUREX Storage Tunnels						*		
III.3	Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility						*		
III.4	242-A Evaporator						*		
III.5	325 Hazardous Waste Treatment Units						*		
III.10	Waste Treatment and Immobilization Plant						*		
III.11	Integrated Disposal Facility						*		
~~III.15~~	~~331-C Storage Unit~~						~~*~~		
III.16	400 Area Waste Management Unit						*		
PART IV									
IV.	UNIT SPECIFIC CONDITIONS FOR CORRECTIVE ACTION								
IV.1	100-NR-1				*	*			
PART V									
V.	UNIT SPECIFIC CONDITIONS FOR UNITS UNDERGOING CLOSURE								
V.1	1325-N Liquid Waste Disposal Facility					*			
V.2	1301-N Liquid Waste Disposal Facility					*			
V.3	1324-N Surface Impoundment & 1324-NA Surface Impoundment					*			
PART VI									
VI.	UNIT SPECIFIC CONDITIONS FOR UNITS IN POST CLOSURE								
VI.1	300 Area Process Trenches							*	
VI.2	183-H Solar Evaporation Basins							*	

CATEGORIES ARE DEFINED AS FOLLOWS:

A. Leased Land	E. TSD Unit Closures (Part V)
B. North Slope and ALE	F. TSD Operating Units (Part III)
C. Interim Status TSD Units	G. TSD Units in Post Closure/Modified Closure (Part VI)
D. Areas Between TSDs (excluding A and B)	

*Condition applies to this category, as modified by applicable footnotes and qualifiers.

Hanford Facility RCRA Permit Change Notice

Part III, Operating Unit Group 3

Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility

Index

Page	Permit Section
Page 2 of 12:	Part III, Operating Unit Group 3, Permit Conditions
Page 3 of 12:	Addendum A, Part A Form
Page 4 of 12:	Addendum B, Waste Analysis Plan (1 of 2)
Page 5 of 12:	Addendum B, Waste Analysis Plan (2 of 2)
Page 6 of 12:	Addendum C, Process Information (1 of 3)
Page 7 of 12:	Addendum C, Process Information (2 of 3)
Page 8 of 12:	Addendum C, Process Information (3 of 3)
Page 9 of 12:	Addendum F, Preparedness and Prevention
Page 10 of 12:	Addendum H, Closure Plan
Page 11 of 12:	Addendum I, Inspection Plan
Page 12 of 12:	Addendum J, Contingency Plan

Submitted by WRPS Co-Operator:

6/2/16

D. Kent Smith Date

Reviewed by DOE-ORP Program Office:

6/2/16

Thomas W. Fletcher Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Part III, Operating Unit Group 3 Permit Conditions:

- Unit Description: Updated Washington State Waste Discharge Permit Number ST0004500 to 2014, and added hyperlink to permit, and added hyperlink to 200 Area ETF Delisting.
- Updated the List of Addenda Specific to Operating Unit Group 3:

Addendum A	Part A Form, dated ~~March 31, 2016~~June 30, 2016
Addendum B	Waste Analysis Plan, dated ~~June 30, 2015~~ June 30, 2016
Addendum C	Process Information, dated ~~December 31, 2014~~June 30, 2016
Addendum D	Groundwater Monitoring, approved April 29, 2014
Addendum E	Security Requirements, dated June 30, 2011
Addendum F	Preparedness and Prevention, dated ~~April 8, 2014~~June 30, 2016
Addendum G	Personnel Training, dated June 30, 2015
Addendum H	Closure Plan, dated ~~June 30, 2011~~June 30, 2016
Addendum I	Inspection Requirements, dated ~~April 8, 2014~~ June 30, 2016
Addendum J	Contingency Plan, dated ~~June 30, 2015~~ June 30, 2016

- Permit Condition III.3.A.1: Deleted "and Chapters" because there are no Chapters.
- Permit Condition III.3.B.2: Corrected referenced Permit Condition III.3.B.1.
- Permit Condition III.3.B.3.b: Corrected referenced to Figure C.2 and C.3.
- Permit Condition III.3.B.7.c and Permit Condition III.3.B.10: Updated Discharge Permit Number ST0004500.
- Permit Condition III.3.C.3: Corrected referenced Permit Condition III.3.C.2
- Permit Condition III.3.C.4: Corrected referenced Permit Condition III.3.C.2
- Permit Condition III.3.O.1.a.1: Corrected referenced Permit Condition II.I.1.
- Permit Condition III.3.O.2.a: Corrected referenced Section C.3.2.
- Permit Condition III.3.O.2.d: Corrected referenced Sections C.3.1 and C.3.4.6.
- Permit Condition III.3.O.2.f: Corrected referenced Section C.3.4.5.
- Permit Condition III.3.P.1.a: Corrected referenced Section C.4.1.5.
- Permit Condition III.3.P.2.b: Corrected referenced Section C.4.4.2.
- Permit Condition III.3.P.2.c: Corrected referenced Section C.4.5.
- Permit Condition III.3.Q.2: Corrected referenced Section I.1.2.3.1.

WAC 173-303-830 Modification Class	Class 1	Class '1	Class 2	Class 3
Please mark the Modification Class:	X			

Enter relevant WAC 173-303-830, Appendix I Modification citation number: A.1

Enter wording of WAC 173-303-830, Appendix I Modification citation: Administrative and informational changes.

Modification Approved: ☒ Yes ☐ No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16 Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum A, Part A Form:

- Header: Editorial updated header, Revision 4 to Revision 4A, and updated date.
- Section III, Name of Facility: Changed "US" to "U.S."
- Section IV, Facility Location: Deleted "825 Jadwin", and inserted "Refer to Permit Attachment 2, Hanford Facility Permit Legal Description". Inserted "Near" before Richland, and deleted zip code "99352".
- Section IV.D, Facility Existence Date: Revised Hanford Facility existence date to "11/19/1980" rather than "03/02/1943".
- Section VII.A, Name/Phone Number: Updated Name, inserted "dangerous waste management units", and updated "Co-Operator Phone Number to "(509) 372-9974".
- Section VII.C, Does the name in VII.A reflect a proposed change in operator: Deleted "Co-Operator* change", and corresponding date.
- Section VIII.A, Facility Owner Information, Name: Inserted "U.S. Department of Energy" and deleted "Kevin W. Smith, Facility Property Owner".
- Section IX, NAICS Codes: Revised NAICS code to use 6-digit code (562211), and deleted NAICS codes that do not apply to LERF and 200 Area ETF operations (54171, and 924110).
- Section X, Other Environmental Permits: Updated section to reflect current environmental permits.
- Section XI, Nature of Business: Updated reference to Washington State Waste Discharge Permit (ST0004500), corrected naming of 200 Area Final Delisting, naming of unit. Deleted "18,927 liters per day" and inserted "listed in Section XII" because the process design capacity for treatment of waste in containers (T04) is identified in Section XII. Inserted text from Section
- Section XIV, Description of Dangerous Waste
  - Format, starting on page 6 of 10 to 10 of 10, removed hard page returns to restore table header. Restoring the header changed the information that resides on pages 6 to the end of the Part A.
  - Consistency, combined T01 (lines 36-70) with S02 (lines 71-105) for tank volume 106,940,410, and deleted T01 lines 36-70.
  - Consistency, for dangerous waste that has more than one waste code, changes the rows below the first row for Columns B, C, and D(1) to be blank, and added "Included with above" in Column D(2) for all the rows below the first row.
- Section XIX, Comments: Deleted information regarding Revision 3A to 4 changes, per Ecology direction this information is to be provided in the PCN Forms.
- Section XV, Map: Revised topographic map to include 2025-ED Load-In-Station that is discussed throughout Addendum C, Process Information. Deleted text "Topographic map is located in the Ecology Library" because all elements required for the topographic map are included in the revised Part A topographic map; as a result this map should be removed from the Ecology Library because the map is no longer needed or current. Added North arrow and scale.
- Section XVII, Photographs: Aerial Photo Title, page 13 of 16, corrected spelling, inserted updated photo, and date photo was taken. Corrected photograph title (Page 17)-deleted "Liquid Effluent Retention Facility" because the photograph only shows 200 Area Effluent Treatment Facility.
- Section XVIII, Certification: Update Co-Operator telephone number.
- Page 19 of 19: Inserted "This page intentionally left blank".

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: : WAC 173-303-830(3)(d), Other Modifications

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: [X] Yes [ ] No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16 Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum B, Waste Analysis Plan (1 of 2):

- Table of Contents and Figure B.1: Deleted Figure B.1, and Figures from Table of Contents. Figure B.1 was deleted because the figure is already provided in Addendum C, Figure C.3 where the systems are described.
- Metric Conversion Chart: Format, moved Metric Conversion Chart to follow Table of Contents, changed page numbering so that B. WASTE ANALYSIS PLAN begins on Page 1 rather than Page 5, and regenerated table of contents.
- Editorial – revised reference for Discharge Permit Number ST0004500, added inline reference, updated hyperlinks, and deleted reference to old ST 4500 early warning values to be consistent with the revised ST0004500 permit to be consistent with the revised 2014 Permit: Sections B.1, B.1.1, B.2.2, B.2.2.1, B.5, B.5.1, B.5.2.2, B.5.2.3, and Table B.4.
- Editorial – revised reference for 200 Area ETF Delisting and Final Delisting: Sections B.1.2, B.2.2, B.2.2.1, B.2.2.1.1, B.5, B.5.1, B.5.2.2, B.5.2.3, Tables B.2, and B.4.
- Editorial – applied format "para keep with next" to bullets: Section B.2.2.3.
- Editorial – document name/number: Sections B.1.1, and B.1.2.
- Editorial – inserted "incorporated by reference by WAC 173-303-910(3)" after 40 CFR 261, Appendix IX: Sections B.1, B.1.1, B.1.2, B.2.2.1, B.5.1, and Tables B.2 and B.4.
- Editorial – provided both standard/metric conversions: Sections B.1.1, B.3.1, B.5, and Tables B.1, B.6, and B.7.
- Editorial – spelled out table acronyms in table footnotes: Table B.1.
- Editorial – unit/component/addendum naming and numbering: Sections B.1, B.1.1, B.2.1.2, B.2.2, B.2.2.1, B.2.2.3, B.2.2.3.1, B.3.1, B.4.1, B.4.1.1, B.4.2, B.5.2.1, B.6.1.2, B.6.2, B.6.3, B.7.1.1.1, B.7.1.2, B.7.2.1, B.7.2.4, B.7.2.6, B.7.3.1, B.7.3.3, Table B.1 and Table B.2. Section B.9 becomes B.8 with deletion of Section B.8, References.
- Editorial – updated references to Figures: Section B.1.1.
- Editorial/grammatical/sentence structure/format (e.g., and, is, which, singular/plural, removed extra bullet, inserted period/comma/return, and hard space to keep text together): Sections B.1, B.1.1, B.1.2, B.2.1.1, B.2.2, B.2.2.1, B.2.2.3, B.2.3, B.2.4, B.3.1, B.5, B.7.3.3, Table B.3, Table B.5, and Table B.7.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: : WAC 173-303-830(3)(d), Other Modifications

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: ☒ Yes ☐ No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16

S. L. Dahl-Crumpler Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum B, Waste Analysis Plan (2 of 2):

- Section B.1.2, Sources of Aqueous Waste: Corrected document number from "DOE/RL-92-97 " to "DOE/RL-92-72". Corrected Permit Condition "I.a.i" to "III.3.B.7" regarding the Final Delisting for 200 Area ETF, and inserted "Final" in front of Delisting Petition and added hyperlink. Added "incorporated by reference by WAC 173-303-910(3)".
- Section B.2.2, Waste Management Decision Process: Corrected information. Aqueous waste is not allowed under the Final Delisting for 200 Area ETF; as a result deleted text referring to the ST 4500 that is not applicable.
- Corrected page numbering (so that Section B begins on page B.1 rather than B.6) and regenerated table of contents.
- Section B.2.2.1.2, State Waste Permit Regulations/Permit: Deleted section because the revised 2014 Discharge Permit Number ST0004500 no longer requires monitoring constituents of concern, and deleted reference to this Section in Section B.2.2.1.
- Section B.3.1, LDR Compliance at LERF: Corrected conversion error that was introduced while rounding and converting back and forth between gallons/liters, using exact capacity of 2,082,000 liters (550,006 gallons).
- Section B.5, Treated Effluent Sampling and Analysis: Corrected the volume of the verification tanks from 2,940,000 liters to 3,025,739 liters (799,316 gallons) using exact capacities consistent with CHPRC ETF Engineering report, which documents tank volumes and the calculations (CHPRC-01900, Revision 2, June 2013).
- Section B.8, References: Deleted reference section and replaced with inline references. Throughout Addendum B updated reference for Discharge Permit Number ST0004500, and inserted hyperlinks to TPA Administrative Record and Ecology website for these inline-referenced documents.
- Table B.4, Rationale for Parameters to be Monitored in Treated Effluent: Modified table heading and footer, updated ST0004500 Discharge Permit Effluent Column per 2014 Permit, applied superscript on "3" after Total Metals, and applied paragraph keep with next to keep Total Metal elements on same page..
- Table B.6, Sample and Analysis Criteria for Influent Aqueous Waste and Treated Effluent: Inserted Standard conversion for metric values in Table footer, and updated Parameters, Analytical Method, Method PQL Sensitivity, and Accuracy/Precision for Method to be consistent with ST0004500 Discharge Permit.
- Table B.7, Sample Containers, Preservative Methods, and Holding Times for 200 Area ETF Generated Waste: Inserted Standard conversion for metric values in Table footer. For consistency, inserted Footnote 1 "*SW 846 or EPA-600 methods are presented unless otherwise noted. Other methods might be substituted if the applicable PQL can be met.*" This Footnote is the same as Footnote 1 in Table B.6, Sample and Analysis Criteria for Influent Aqueous Waste and Treated Effluent. The footnote provides flexibility when working with offsite laboratories that use equivalent analytical methods. Some of these laboratories use solid waste (SW-846) and some use water quality (EPA-600), or a combination. Renumbered existing Footnotes.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: : WAC 173-303-830(3)(d), Other Modifications

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: [X] Yes [ ] No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16 Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum C, Process Information (1 of 3):

- Corrected page numbering (so that Section C begins on page C.1 rather than C.6) and regenerated table of contents.
- Updated Table of Contents: Regenerated the table of contents. Deletion of Figure C.4 resulted in renumbering of Figures.
- Updated reference to Discharge Permit Number ST0004500 to be consistent with the revised 2014 Permit and added link to document: Sections C, C.2.2, and C.2.3.
- Consistency Figure references/Figure title/corrected referenced figure numbers: Sections C.2, C.2.1, C.2.2, C.2.3, C.2.4, C.2.5.3, C.3, C.3.2, C.3.4.1,C.3.4.3, C.4, C.4.3.2.2, C.5.2.1, C.5.2.1.1, C.5.2.4, C.5.2.5, C.5.6, Figure C.11, and Figure C.14.
- Consistency Section references/Section title: Sections C.2, C.2.4, C.2.5.2, C.4, C.4.1.2, C.4.3.1.1, C.4.3.2.2, and C.4.5.
- Editorial unit/component/addendum naming: Sections C, C.2, C.2.1, C.2.2, C.2.3, C.2.4, C.2.5, C.2.5.1, C.2.5.2, C.2.5.3, C.2.5.5, C.2.5.6, C.3, C.3.2, C.3.4, C.3.4.1, C.3.4.2, C.3.4.3, C.3.4.4, C.3.4.5, C.3.4.6, C.4.3, C.4.1, C.4.1.1, C.4.1.2, C.4.1.3, C.4.1.4, C.4.1.5, C.4.2, C.4.3, C.4.3.1, C.4.3.1.1, C.4.3.1.2, C.4.3.2.1, C.4.3.2.2, C.4.4.1, C.4.4.2, C.4.5, C.4.6, C.5.3, C.5.5.2, C.6.1, C.7.2, Table C.3, Table C.4, Table C.5, Table C.6, Table C.7, and Table C.8.
- Editorial standard/metric conversions: Sections C.1, C.2, C.3, C.3.1, C.3.2, C.3.4.1, C.3.4.3, C.4.3.1.1, C.4.3.1.2, C.4.3.2.2, C.4.5, C.5, C.5.2.1, C.5.2.1.1, C.5.2.1.2, C.5.2.1.3, C.5.2.1.4, C.5.2.1.5, C.5.2.2, C.5.2.3, C.5.2.4, C.5.3, C.5.3.1, C.5.3.2, C.5.4.1, C.5.4.2, C.5.5, C.5.5.1, C.5.5.2, C.5.5.3, C.5.6, C.5.7, C.5.8, C.6.1, C.6.2.1, C.6.2.2, C.6.2.3, C.6.3.2, Table C.5, C.8, C.9, and C.10.
- Editorial, documents/drawings/codes and standards provided/corrected document title/number: Sections C.3.4.1, C.3.4.2, C.3.4.3, C.4.1, C.4.1.1, C.4.1.4, C.4.1.5, C.4.2, C.4.3.1, C.4.3.1.1, C.5.2.1, C.5.2.1.1, C.5.2.1.2, C.5.2.1.3, C.5.2.1.4, C.5.2.3, C.5.2.4, C.5.4.1, C.5.4.2, C.5.5, C.5.5.3, C.5.6, C.5.7, C.5.8, C.6.2.2, Table C.1, Table C.2, Table C.3, and Table C.9.
- Formatted table: Table C.1, Table C.2, Table C.3, Table C.5, Table C.6, Table C.7, and Table C.10.
- Grammatical/Format/Sentence Structure (e.g., to, the, deleted/inserted hard returns, hard spaces, blank page, extra spaces, hyphens, deleted bullet, punctuation, grammar, spelling, paragraph format/keep with next, tabs, and spelling): Sections C, C.1, C.2.2, C.2.4, C.2.5.1, C.2.5.2, C.2.5.3, C.2.5.5, C.3, C.3.2, C.3.4, C.3.4.1, C.3.4.3, C.4, C.4.1, C.4.1.1, C.4.1.2, C.4.1.5, C.4.3.1.1, C.4.3.1.2, C.4.3.2.2, C.5.2.1, C.5.2.1.1, C.5.2.1.2, C.5.2.3, C.5.2.4, C.5.3.1, C.5.3.3, C.5.4.2, C.5.5, C.5.5.1, C.5.5.2, C.5.6, C.6.1, C.6.2.1, C.6.2.2, C.6.3.2, C.7.2,Table C.3, Table C.7, Table C.8, and Table C.10.
- Inserted text to refer to Table C.5 for volumes and dimensions, and deleted corresponding tank volumes and dimensions: Sections C.4.1.2, and C.4.1.3.
- Section C.2, 200 Area ETF Process Description: Inserted reference to Section C.3.4, for containers and Section C.4.3 for tank systems, and deleted duplicate text already discussed in those sections. Moved text regarding removal of liquids to Section C.3.4.2. Deleted "approximately".
- Section C.2.5.2, Vessel Off Gas System: Capitalized section title.
- Section C.2.5.6, Utilities: Deleted "of the ETF".
- Section C.3, Containers: Moved text from Sections C.3.1 and C.3.4.3 regarding maximum volume of waste that can be stored in containers and deleted the information from Sections C.3.1 and C.3.4.3. Inserted "Containers at the Load-In Station are transferred into one of the Load-In Station tanks, surge tank, or directly to the LERF".

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: : WAC 173-303-830(3)(d), Other Modifications

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: ☒ Yes ☐ No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crampler 6/13/16 Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum C, Process Information (2 of 3):

- Section C.3.1, Description of Container: Moved text regarding maximum quantity of mixed waste to Section C.3, Containers.
- Section C.3.4, Containment Requirements for Managing Containers: Inserted text "Section C.2.1, and Section C.4.3.1.2 discuss secondary containment at the Load-In Station."
- Section C.3.4.1, Secondary Containment System Design: Clarified section pertaining to "Container" secondary containment.
- Section C.3.4.3, Containment System Capacity: Replaced "the ETF" with "building 2025-E". Moved text regarding maximum quantity of mixed waste to Section C.3, Containers.
- Section C.3.4.4, Control of Run-on: Replaced "the ETF" with "building 2025-E".
- Section C.3.4.5, Removal of Liquids from Containment Systems: Inserted "Additional information on removal of liquids is provided in Section C.2, and Section C.4.3.1.2."
- Section C.4, Tank Systems: Inserted references to Section C.4.1.1, Table C.5, Table C.6, Figure C.2, and Table C.7. Deleted "and" and "in the 200 Area ETF".
- Section C.4.1.2, Design Information for Tanks Located Outside of Building 2025-E: Removed duplicate text regarding tank volumes and dimensions, and inserted text "Table C.5, 200 Area ETF Tank Systems Information, provides individual tank volumes, dimensions, and construction materials for tanks located outside building 2025-E".
- Section C.4.1.3, Design Information for Tanks Located Inside Building 2025-E: Removed text regarding tank volumes and dimensions and inserted "Table C.5, 200 Area ETF Tank Systems Information, provides individual tank volumes, dimensions, and construction materials for tanks located outside building 2025-E."
- Section C.4.3.1.1, Common elements: Listed "Sump tanks" as separate bullet, and corrected reference title for HPS-SDC-4.1, Revision 11.
- Section C.4.3.1.2, Specific Containment Systems: Clarified text for Load-In Station Secondary Containment, and Process Area Secondary Containment, and inserted tank numbers for the three Verification Tanks. Deleted surge tank capacity because this section addresses secondary containment capacity, and information is in Table C.5. Under Load-In Station secondary containment, modified text to read, "The bay in the Load-In Station building is sloped to channel spills or leaks from containers to the Load-In Station pit. Table C.8 provides additional information on the protective coating for the concrete pad." Under Load-In Station, 4th paragraph, deleted "The pad does not have protective coating because it would experience excessive wear from the vehicle traffic."; and inserted "The bay in the Load-In Station building is sloped to channel spills or leaks from containers to the Load-In Station pit. Coated concrete surfaces are provided for storage and unloading locations where spills and leaks could potentially occur." Under Surge Tank Secondary Containment, updated specifications regarding the dike to use exact specifications.
- Section C.4.3.2.2, Ancillary Equipment: Inserted "Table C.6, and C.7" as additional references to Figure C.2.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: : WAC 173-303-830(3)(d), Other Modifications

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: ☒ Yes ☐ No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16 Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum C, Process Information (3 of 3):

- Section C.4.4.2, Overfilling Prevention: Clarified text regarding sump tank overfill, and inserted information under Tanks to address cases when the liquid level monitors are out-of-service.
- Section C.5, Surface Impoundments: Clarified text regarding LERF basin overflow volumes.
- Section C.5.2.1.1, Material Specifications: Inserted "pipe" in several places for clarity.
- Section C.5.2.4.1, Liner Repairs During Operations: Inserted text to incorporate changes made in the Class 2 mod approved by Ecology 11/24/14, which was omitted during the transition of configuration control of the Permit from the MSA to Ecology. 14-AMRP-0245 (8/11/14) available at http://pdw.hanford.gov/arpir/index.cfm/viewdoc?accession=0084874 14-NWP-238 (11/24/14) available at http://pdw.hanford.gov/arpir/index.cfm/viewdoc?accession=1412031006 15-AMRP-0034 (12/8/14) available at http://pdw.hanford.gov/arpir/index.cfm/viewdoc?accession=0082932h. The Class 2 modification inserted "others knowledgeable in liner repair" because the liner vendor is not always available (e.g. went out of business) or not always the best choice based on the particular need. Therefore, other qualified vendors or others, such as a professional engineer that has adequate knowledge and experience to make recommendations in liner repairs. The criteria for selecting a person or company to make liner repair recommendations is determined by the Permittees for the LERF basins. Selection criteria could include educational background, related experience, and professional qualifications.
- Section C.5.3.1, Freeboard: Inserted "operating capacity" to clarify text and for consistency with Section I.1.2.3.1, Overtopping Control.
- Section C.5.3.2, Immediate Flow Shutoff: Inserted text to clarify that the calculation is from the maximum operating level to overflow level, and deleted the text from "(i.e., …to end of paragraph.
- Section C.5.4.2, Dike Stability and Protection: Inserted "to" and "g-force" in several places for clarity.
- Section C.5.6, Double Liner and Leak Detection, Collection, and Removal System: Inserted "pipe" in two places for clarity.
- Table C.5, 200 Area ETF Tank Systems Information: Added Standard unit of measure, deleted the last column because it is redundant to Column 2, corrected volume of the verification tanks to use exact tank capacities, and updated table footnotes.
- Table C.8, Concrete and Masonry Coatings: Formatted table-inserted new column for standard unit of measure, updated Table and footnotes with current products that are equivalent or superior products because products listed are no longer manufactured. Updated sub-headings to clarify locations.
- Table C.9, Geomembrane Material Specifications: Corrected typographical errors, spelled out acronyms in table and deleted table footnotes for %, g, min, h, max, m, and mm.
- Figure C.2, Plan View of the 200 Area ETF: Updated figure to include areas referenced in text.
- Figure C.3, 2025-E Building Ground Floor Plan: Updated Figure and title to include area referenced in text.
- Figure C.4, 200 Area ETF: Deleted Figure C.4 because the information is provided in Figures C.2 and C.3; as a result Figures C.4 through C.17 were renumbered throughout document.
- Section C.5 and C.5.2.3: Updated standard/metric conversions for accuracy; no design or capacity changes were made.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: WAC 173-303-830(3)(d), Other Modifications

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: ☒ Yes ☐ No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16 Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum F, Preparedness and Prevention:

- Corrected page numbering (so that Section F begins on page F.1 rather than F.5) and regenerated table of contents.
- Editorial standard/metric conversions: Sections F.1.2, F.2.2, and F.2.5.
- Editorial hard space/hyphen, spaces, removed extra return: Sections F.1.1, and F.1.1.2
- Editorial unit/component naming: Sections F.1.1.3, F.2.1, F.2.3, and F.2.5.
- Section F.2.3, Water Supplies: First paragraph, replaced "at other times" with "when waste transfers are not occurring." Second paragraph, replaced "at other times" with "when waste process and/or waste transfer operations are not occurring". Made sentence structure change.
- Section F.2.4, Equipment and Power Failure: Grammatical, changed "effected" to "affected", deleted "in the control room", and clarified text on the uninterruptible power supply.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: WAC 173-303-830(3)(d), Other Modifications

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: ☒ Yes ☐ No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16 Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum H, Closure Plan:

- Corrected page numbering (so that Section H begins on page H.1 rather than H.5) and regenerated table of contents.
- Corrected referenced Section/Permit Condition numbers: Sections H.3.1, H.3.4.2, H.3.4.3, H.3.4.5, H.3.4.7, H.5.2, H.5.3, and H.6.
- Editorial hard space/hyphen: Section H.2.1.
- Editorial inserted hyperlink: Sections H.2.1, H.2.3, H.3.1, H.3.4.2, H.3.4.3, H.3.4.5, H.3.4.7, H.5.2, and H.5.3.
- Editorial standard/metric conversions: Sections H.2.1, H.3.3, H.3.4.2, and H.3.4.5.
- Editorial unit/component naming: Section H.1
- Editorial, documents/drawings provided document title/number: Sections H.2.3, and H.3.4.2.
- Section H.3.4.2, Drainage Layer and Secondary Liner: Corrected dimensions for the thick layer of soil/bentonite to be consistent with the information in Addendum C, Process Information, Section C.5.2.1.
- Section H.6, Schedule for Closure: Corrected Permit reference.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: WAC 173-303-830(3)(d), Other Modifications.

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: [X] Yes [ ] No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16
Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum I, Inspection Plan:

- Corrected page numbering (so that Section I begins on page I.1 rather than I.5) and regenerated table of contents.
- Editorial, page break: Inserted hard return after Section I.1.4.
- Editorial standard/metric conversions: Section I.1.2.3.1.
- Editorial unit/component naming: Sections I.1.2.2.1, I.1.2.2.3, and Table I.1.
- Section I.1.2.2.1, Overfill Protection: Clarified text to be consistent with Section C.4.4.2.
- Section I.1.2.2.4: Updated Section reference.
- Section I.1.2.3.1, Overtopping Control: Corrected freeboard information to be consistent with information provided in Section C.5.3.1, and distinguished between operating level and operating capacity.
- Section I.1.2.2.3, Secondary Containment Leak Detectors: Clarified monitoring is performed in the 200 Area ETF Control Room, and replaced "at other times" with "when processing operations or waste transfers are not occurring".
- Section I.1.2.3.3, Leak Detection: Inserted text from Class 2 modification Ecology approved 11/24/14, which was omitted during the transition of configuration control of the Permit from the MSA to Ecology. Refer to 14-AMRP-0245 (8/11/14) available at http://pdw.hanford.gov/arpir/index.cfm/viewdoc?accession=0084874, 14-NWP-238 (11/24/14) available at http://pdw.hanford.gov/arpir/index.cfm/viewdoc?accession=1412031006, and 15-AMRP-0034 (12/8/14) available at http://pdw.hanford.gov/arpir/index.cfm/viewdoc?accession=0082932h. Formatted numbered list for the two methods, and inserted text to clarify where leak detectors alarm and are monitored. Deleted "or pump operating time readings". Editorial corrected naming, inserted spaces, and corrected naming.
- Section I.1.2.3.6, Container Inspection: Corrected Section reference.
- Section I.1.3: Editorial inserted space.
- Section I.1.5, Instrumentation Monitoring: Inserted level 3 heading. Footnote text from Table I.2 was moved to this section and was revised to delete "of a malfunction of one of" and insert "or level indicators for Sump Tank 1 or Sump Tank 2 are out of service", insert references to Addendum C, Process Information, and replace "while the facilities are in operation" with "each operating day (WAC 173-303-640)". The new text for Section I.1.5, Instrumentation Monitoring:

  "Continuous monitoring applies to the electronic monitoring performed in the 200 Area ETF Control Room for this instrumentation during 200 Area ETF processing operations and/or 2025-E Load-In Station transfers. Data from alarms, leak detectors, and level transmitters are monitored daily in the 200 Area ETF Control Room when waste transfers are not occurring (see C.2.5.1). In cases where this instrumentation is out of service (e.g., calibration, power failures, or maintenance) daily visual inspections will be performed in accordance with WAC 173-303-640, using the alternate methods discussed in Addendum C, Section C.1 for leak detection, Section C.4.3.1.2 for level inspection, and Section C.4.4.2 for overfill prevention will be followed.

  In the event the electronic leak detectors or level indicators for Sump Tank 1 or Sump Tank 2 are out of service, daily visual inspections will be performed each operating day (WAC-173-303-640).

  Inspections pertaining to instrumentation monitoring is provided in Table I.2."
- Table I.1, Visual Inspection Schedule for LERF and 200 Area ETF: Under Secondary Treatment Train, Thin Film Dryer Room, changed "tanks" to "piping" inspections because there are no tanks located in the Thin Film Dryer Room. Moved table title to first row of Table and marked as table header. Clarified text for thin film dryer room and container storage inspections, replaced "to" with "the", modified table footnotes to address use of the camera system for inspections. Updated footnote numbering.
- Table I.2, Inspection Plan for Instrumentation Monitoring: Formatted table to fit contents, moved existing table footnotes to new Section I.1.5 (before Table I.2), and deleted table footnotes from the table. Corrected component naming for "Sump Tank 1" and "Sump Tank 2". Deleted footnote text pertaining to Addendum J, Contingency Plan.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: WAC 173-303-830(3)(d), Other Modifications

Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

Modification Approved: [X] Yes [ ] No (state reason for denial)

Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16 Date

Hanford Facility RCRA Permit Change Notice

Unit:	Permit Part
Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility	**Part III, Operating Unit Group 3**

Description of Modification:

Addendum J, Contingency Plan:

- Corrected page numbering (so that Section J. Contingency Plan starts on page J.1 rather than J.5) and regenerated table of contents.
- Editorial unit/component naming: Sections J, J.1, J.2, J.3, J.3.1.1, J.3.1.2, J.3.2, J.3.2.4, J.3.2.5.1, J.3.4, J.3.5, J.4, J.4.1, J.4.2, J.4.3, J.4.6, J.6, J.7, and Figure J.1.
- Editorial applied italics to "Atomic Energy Act": Section J.3.2.5
- Editorial/Format: Sections J.4.1, J.4.2, J.4.3, J.4.4, J.4.5, J.5, J.7, and Tables J.1.
- Table J.1, Hanford Facility Documents Containing Contingency Plan Requirements of WAC 173-303-350(3): Formatted table for banded rows, placed table title in table header to have table heading on multiple pages, and used hard hyphen's to keep document numbers on 1 line.
- Section J.3.2.5, Hazardous Material, Dangerous and/or Mixed Waste Spill: For consistency with DOE/RL-94-02, *Hanford Site Emergency Management Plan* (Permit Attachment 4) and BEPs corrected acronym from "SWIMS" to "SWIM". Ventilation shutdown is covered under the second bullet to place the plant in a safe shutdown configuration.
- Section J.4.1, Fixed Emergency Equipment: Inserted location descriptions for safety shower/eye wash stations, and sorted the safety shower/eye wash stations by location, deleted the number "1" in front of each location because this column is for location. Deleted "1 – 2025-E South Wall of Process Area" because this location is the same location as "2025-E Rm 131, South Process Area".
- Section J.4.5, Spill Control and Containment Supplies: Sorted locations by area. Deleted the numbers listed in the "Location Column" because this column is for location. Deleted "CONEX" and made formatting changes.

WAC 173-303-830 Modification Class	Class 1	Class '1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: WAC 173-303-830(3)(d), Other Modifications.
Enter wording of WAC 173-303-830, Appendix I Modification citation: Request modification reviewed and approved as a Class 1 prime.

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Reason for denial:

Reviewed by Ecology:

S. L. Dahl-Crumpler 6/13/16 Date

Remove and Replace the Following Pages:

- Part III, Operating Unit Group 3, Permit Conditions
- Addendum A, Part A Form
- Addendum B, Waste Analysis Plan
- Addendum C, Process Information
- Addendum F, Preparedness and Prevention
- Addendum H, Closure Plan
- Addendum I, Inspection Plan
- Addendum J, Contingency Plan

PART III, OPERATING UNIT GROUP 3 PERMIT CONDITIONS
LIQUID EFFLUENT RETENTION FACILITY & 200 AREA EFFLUENT TREATMENT FACILITY

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PART III, OPERATING UNIT GROUP 3 PERMIT CONDITIONS
LIQUID EFFLUENT RETENTION FACILITY & 200 AREA EFFLUENT TREATMENT FACILITY

UNIT DESCRIPTION:

The Liquid Effluent Retention Facility (LERF) and 200 Area Effluent Treatment Facility(200 Area ETF) consists of an aqueous waste treatment system that provides treatment, storage integral to the treatment process, and storage of secondary wastes from the treatment process for a variety of aqueous mixed waste. The 200 Area ETF is located in the 200 East Area. Aqueous wastes managed by the 200 Area ETF include process condensate from the LERF and 200 Area ETF and other aqueous waste generated from onsite remediation and waste management activities.

The LERF consists of three lined surface impoundments, or basins. Aqueous waste from LERF is pumped to the 200 Area ETF for treatment in a series of process units, or systems, that remove or destroy essentially all of the dangerous waste constituents. The treated effluent is discharged to a State-Approved Land Disposal Site (SALDS) north of the 200 West Area, under the authority of a Washington State Waste Discharge Permit Number ST0004500 (Ecology 20142000) and 200 Area ETF Delisting (40 CFR 261, Appendix IX, Table 2). Construction of the LERF began in 1990. Waste management operations began at LERF in April 1994. Construction of the 200 Area ETF began in 1992. Waste management operations began at 200 Area ETF in November of 1995.

This Chapter provides unit-specific Permit conditions applicable to the dangerous waste management units for LERF and 200 Area ETF.

LIST OF ADDENDA SPECIFIC TO OPERATING UNIT GROUP 3

Addendum A	Part A Form, dated ~~March 31, 2015~~ June 30, 2016
Addendum B	Waste Analysis Plan, dated ~~June 30, 2015~~ June 30, 2016
Addendum C	Process Information, dated ~~December 31, 2014~~ June 30, 2016
Addendum D	Groundwater Monitoring, approved April 29, 2014
Addendum E	Security Requirements, dated~~,~~ June 30, 2011
Addendum F	Preparedness and Prevention, dated ~~April 8, 2014~~ June 30, 2016
Addendum G	Personnel Training, dated June 30, 2015
Addendum H	Closure Plan, dated ~~June 30, 2011~~ June 30, 2016
Addendum I	Inspection Requirements, dated ~~April 8, 2014~~ June 30, 2016
Addendum J	Contingency Plan, dated ~~June 30, 2015~~ June 30, 2016

DEFINITIONS

State and federal delisting actions: The state delisting action pursuant to WAC 173-303-910(3), August 8, 2005, and the federal delisting action appearing in 40 CFR 261, Appendix IX, Table 2 applicable to the United States, Department of Energy, Richland, Washington.

ACRONYMS

LERF and 200 Area ETF 200-Area Liquids Processing Facility

III.3.A COMPLIANCE WITH UNIT-SPECIFIC PERMIT CONDITIONS

III.3.A.1 The Permittees will comply with all Permit Conditions in this Chapter and its Addendums ~~and Chapters~~ with respect to dangerous waste management and dangerous waste management units in LERF and 200 Area ETF, in addition to requirements in Permit Part I and Part II.

III.3.B GENERAL WASTE MANAGEMENT

III.3.B.1 The Permittees are authorized to accept dangerous and/or mixed waste for treatment in dangerous waste management units that satisfies the waste acceptance criteria in Permit Addendum B according to the waste acceptance procedures in Permit Addendum B. [WAC 173-303-300]

III.3.B.2 The Permittees are authorized to manage dangerous and/or mixed wastes physically present in the dangerous waste management units in LERF and 200 Area ETF as of the effective date of this Permit according to the requirements of Permit Condition III.~~15~~3.B.1.

III.3.B.3 The Permittees are authorized to treat and/or store dangerous/mixed waste in the dangerous waste management units in LERF and 200 Area ETF according to the following requirements:

III.3.B.3.a The Permittees are authorized to treat, and store as necessary in support of treatment, dangerous waste in the 200 Area ETF tank systems identified in Permit Addendum C, Section C.2, and Section C.4 according to the Permit Conditions of this Chapter.

III.3.B.3.b The Permittees are authorized to store and treat those dangerous and/or mixed waste identified in Permit Addendum C, Section C.3, in containers according to the requirements of this Chapter. All container management activities pursuant to this Permit Condition will take place within the container storage areas or within the 200 Area ETF process area identified in Permit Addendum C, Figures C.2~~3~~ and C.3~~4~~.

III.3.B.3.c Treatment in containers authorized by Permit Condition III.3.B.3.b is limited to decanting of free liquids, and addition of sorbents to free liquids. The Permittees will ensure that sorbents are compatible with wastes and the containers. Sorbents will be compliant with the requirements of WAC 173-303-140(4)(b)(iv), incorporated by reference.

III.3.B.3.d The Permittees are authorized to treat aqueous waste in LERF Basins (Basins 42, 43 and 44) subject to the following requirements:

III.3.B.3.d.1 Following treatment in a LERF basin, aqueous wastes must be treated in 200 Area ETF according to Permit Conditions III.3.B.3.a through c.; [40 CFR 268.4(2)(iii), incorporated by reference by WAC 173-303-140]

III.3.B.3.d.2 The Permittees must ensure that for each basin, either supernatant is removed on a flow-through basis, to meet the requirement of 40 CFR 268.4(a)(2)(ii) incorporated by reference by WAC 173-303-140, or incoming waste is shown to not contain solids by either: (1) sampling results showing the waste does not contain detectable solids, or (2) filtering through a 10 micron filter;[WAC 173-303-815(2)(b)(ii)]

III.3.B.4 The Permittees will maintain the physical structure of the LERF and 200 Area ETF as documented in the applicable sections of Permit Addendum C, Section C.2. [WAC 173-303-630(7), WAC 173-303-640(3), WAC 173-303-640(4)]

III.3.B.5 The Permittees are authorized to use treated effluent for recycle/makeup water purposes at the 200 Area ETF as outlined in Permit Addendum C, Section C.2.5.5, and the letters dated August 19, 2005, EPA Region 10 to Keith A. Klein; and August 8, 2005, Department of Ecology to Keith A. Klein. [WAC 173-303-815 (2)(b)(ii)]

III.3.B.6 The Permittees will maintain and operate systems for the 200 Area ETF documented in Permit Addendum C, Section C.2.5 as necessary for proper operation of the 200 Area ETF, compliance with the conditions of this Permit, and protection of human health and the environment. For purposes of this Permit Condition, the Monitor and Control System documented in Permit Addendum C, Section C.2.5.1, is considered to include all

indicators, sensors, transducers, actuators and other control devices connected to but remote from the centralized monitor and control system (MCS) computer.

III.3.B.7 The Permittees must complete the following requirements prior to acceptance for treatment in 200 Area ETF aqueous waste streams with listed waste numbers subject to the requirements of the State and Federal delisting: [WAC 173-303-815(2)(b)(ii)]

III.3.B.7.a The Permittees will prepare a written waste processing strategy according to the requirements of the State and Federal Delisting Actions Conditions (1)(a)(ii) and (1)(b), incorporated by reference, and Permit Addendum B, Section B.2.2.2.

III.3.B.7.b The waste processing strategy required by Permit Condition III.3.B.7.a, must document the proposed processing configuration for the 200 Area ETF, operating conditions for each processing unit, and the expected treated effluent characteristics based on the process model and treatability envelope data required by State and Federal Delisting Conditions (1)(a)(ii) and (1)(b).

III.3.B.7.c The written waste processing strategy required by Permit Condition III.3.B.7.a must demonstrate that the projected treated effluent characteristics satisfy the delisting exclusion limits in State and Federal Delisting Condition (5) of the state and federal delisting actions, and the discharge limits of the Discharge Permit Number ST0004500 (Ecology 2014)~~State Discharge Permit ST-4500.~~

III.3.B.7.d The Permittees will place a copy of the written waste processing strategy required by Permit Condition III.3.B.7.a in the Hanford Facility Operating Record, LERF and 200 Area ETF file as part of the documentation of waste streams accepted for management at the 200 Area ETF.

III.3.B.8 Treatment of aqueous waste streams in the 200 Area ETF with listed waste numbers that are subject to the requirements of the state and federal delisting actions must comply with the requirements of State and Federal Delisting Condition (1)(c), incorporated by reference. [WAC 173-303-815 (2)(b)(ii)]

III.3.B.9 The Permittees will manage treated effluent in the final verification tanks according to the requirements of the State and Federal Delisting Conditions (3) and (5), incorporated by reference. [WAC 173-303-815 (2)(b)(ii)]

III.3.B.10 The Permittees will manage treated effluent from the 200 Area ETF according to the requirements of the Discharge Permit Number ST0004500 (Ecology 2014)~~State Waste Discharge Permit ST-4500~~ and State and Federal Delisting Condition (7). [WAC 173-303-815(2)(b)(ii)]

III.3.B.11 The Permittees will ensure compliance with treatment standards (40 CFR 268, incorporated by reference by WAC 173-303-140) applicable to treated effluent prior to discharge to the State Authorized Land Disposal Site (SALDS), the delisting criteria at 40 CFR 261, Appendix IX, Table 2, and the corresponding state-approved delisting (dated August 8, 2005, all incorporated by reference). Sampling and analysis necessary for these demonstrations must meet the corresponding requirements in Permit Addendum B. [WAC 173-303-140, WAC 173-303-815 (2)(b)(ii)]

III.3.C WASTE ANALYSIS

III.3.C.1 The Permittees will comply with requirements in Permit Addendum B for sampling and analysis of all dangerous and/or mixed waste required by conditions in this Chapter. [WAC 173-303-300]

III.3.C.2 The Permittees will have an accurate and complete waste profile as described in Permit Addendum B, Section B.2.1.2, for every waste stream accepted for management in LERF and 200 Area ETF dangerous waste management units. [WAC 173-303-380 (1)(a), (b)]

III.3.C.3 The Permittees will place a copy of each waste profile required by Permit Condition III.~~1~~53.C.2 in the Hanford Facility Operating Record, LERF and 200 Area ETF file required by Permit Condition II.I.1.j. [WAC 173-303-380 (1)(a), (b)]

III.3.C.4 The Permittees will make a copy of the waste profile required by Permit Condition III.~~1~~53.C.2 available upon request. [WAC 173-303-380 (1)(a), (b)]

III.3.C.5 Records and results of waste analysis described in this Permit will be maintained in the Hanford Facility Operating Record, LERF and 200 Area ETF file required by Permit Condition II.I.1.b. [WAC 173-303-380 (1)(a), (b)]

III.3.D RECORDKEEPING AND REPORTING

III.3.D.1 The Permittees will place the following into the Hanford Facility Operating Record, LERF and 200 Area ETF file required by Permit Condition II.I.1:

III.3.D.1.a Records required by WAC 173-303-380 (1)(k), and -(o) incorporated by reference.

III.3.D.1.b Records and results of waste analysis, waste determinations (as required by Subpart CC) and trial tests required by WAC 173-303-300, General waste analysis, and by 40 CFR §264.1034,§264.1063, §264.1083, §265.1034, §265.1063, §265.1084, §268.4(a), and §268.7; [WAC 173-303-310(2)]

III.3.D.1.c An inspection log, summarizing inspections conducted pursuant to Permit Condition III.3.H.1; [WAC 173-303-380(1)(e)]

III.3.D.1.d Records required by the State and Federal Delisting Condition (6), incorporated by reference; [WAC 173-303-815 (2)(b)(ii)]

III.3.E SECURITY

III.3.E.1 The Permittees comply with the Security requirements specific to the LERF and 200 Area ETF in Addendum E and Permit Attachment 3 as required by Permit Condition II.M. [WAC 173-303-310(2)]

III.3.F PREPAREDNESS AND PREVENTION

III.3.F.1 The Permittees will comply with the Preparedness and Prevention requirements specific to LERF and 200 Area ETF in Addendum F. [WAC 173-303-340]

III.3.G CONTINGENCY PLAN

III.3.G.1 The Permittees will comply with Addendum J, Contingency Plan, in addition to the requirements of Permit Condition II.A when applicable. [WAC 173-303-350]

III.3.H INSPECTIONS

III.3.H.1 The Permittees will comply with Addendum I in addition to the requirements of Permit Condition II.X. [WAC 173-303-320]

III.3.I TRAINING PLAN

III.3.I.1 The Permittees will include the training requirements described in Addendum G of this Chapter specific to the dangerous waste management units and waste management activities at LERF and 200 Area ETF into the written training plan required by Permit Condition II.C.

III.3.J	**GENERAL REQUIREMENTS**	
III.3.J.1	The Permittees will comply with the requirements of WAC 173-303-395(1), incorporated by reference, for prevention of reaction of ignitable, reactive, or incompatible wastes.	
III.3.K	**CLOSURE**	
III.3.K.1	The Permittees will close dangerous waste management units in the LERF and 200 Area ETF in accordance with Addendum H, Closure Plan, and Permit Condition II.J. [WAC 173-303-610(3)(a)]	
III.3.L	**POST CLOSURE – RESERVED**	
III.3.M	**CRITICAL SYSTEMS – RESERVED**	
III.3.N	**RESERVED**	
III.3.O	**CONTAINERS**	
III.3.O.1	Container Storage and Treatment Unit Standards	
III.3.O.1.a	As part of or in addition to the requirements of Permit Condition III.3.B.2, the Permittees will ensure the integrity of container storage secondary containment and the chemically resistant coating described in Addendum C, Section C.3.4.1 as necessary to ensure any spills or releases to secondary containment do not migrate to the underlying concrete or soils.	
III.3.O.1.a.1	Include documentation of any damage and subsequent repairs in the Hanford Facility Operating Record, LERF and 200 Area ETF file required by Permit Condition II.~~I~~I.1.	
III.3.O.2	Container Management Standards	
III.3.O.2.a	The Permittees will maintain and manage wastes in accordance with the requirements of Addendum C, Section C.3.2~~4.3.2, and Section 4.3.2~~. [WAC 173-303-630(2)]	
III.3.O.2.b	The Permittees will label containers in accordance with the requirements of Addendum C, Section C.3.2, and Section C.3.3. [WAC 173-303-630(3)]	
III.3.O.2.c	The Permittees will comply with the requirements for managing wastes in containers in WAC 173-303-630(5), incorporated by reference.	
III.3.O.2.d	The Permittees will ensure wastes are compatible with containers and with other wastes stored or treated in containers within the 200 Area ETF according to the requirements of Addendum C, Section C.3.1 and C.3.4.6~~C.3.4.3~~. [WAC 173-303-630(4), WAC 173-303-630(9)]	
III.3.O.2.e	The Permittees may treat wastes in containers via decanting of free liquids and addition of sorbents. The Permittees may not use addition of sorbents for purposes of changing the treatability group of a waste with respect to the land disposal restriction standards of 40 CFR 268, incorporated by reference by WAC 173-303-140.	
III.3.O.2.f	The Permittees will remove any accumulated liquids from container storage areas in 200 Area ETF according to the requirements of Addendum C, Section C.3.4.5~~C.3.4.2~~, to ensure containers are not in contact with free liquids and to prevent overflow of the container storage area secondary containment.	
III.3.O.2.g	The Permittees will comply with the requirements for air emissions from containers in Addendum C, Section C.6.3.2. [WAC 173-303-692]	

III.3.P TANK SYSTEMS

III.3.P.1 Tank System Requirements

III.3.P.1.a The Permittees will develop a schedule for conducting integrity assessments (IA). The schedule will meet the requirements of Addendum C, Section C.4.1.5~~C.4.2~~, and consideration of the factors in WAC 173-303-640(2)(e) or WAC 173-303-640(3)(b) as applicable:

III.3.P.1.b The Permittees will maintain a copy of the schedule required by Permit Condition III.3.P.1.a, in the Hanford Facility Operating Record, LERF and 200 Area ETF file, and conduct periodic integrity assessments according to the schedule. The Permittees will document results of integrity assessments conducted according to the IA in the Hanford Facility Operating Record, LERF and 200 Area ETF file.

III.3.P.1.c For existing tank systems, if a tank system is found to be leaking, or is unfit for use, the Permittees must follow the requirements of WAC 173-303-640(7), incorporated by reference. [WAC 173-303-640(3)(b)]

III.3.P.2 Tank System Operating Requirements

III.3.P.2.a The Permittees will comply with the requirements of WAC 173-303-640(5)(a), incorporated by reference.

III.3.P.2.b The Permittees will comply with the requirements of Addendum C, Section C.4.4.2~~C.4.5.2~~. [WAC 173-303-640(5)(b)]

III.3.P.2.c The Permittees will comply with the requirements of Addendum C, Section C.4.5~~C.4.6~~. [WAC 173-303-640(5)(d)]

III.3.P.2.d The Permittees will comply with the requirements of WAC 173-303-640(7), incorporated by reference, in response to spills or leaks from tanks systems at 200 Area ETF. [WAC 173-303-640(5)(c)]

III.3.P.2.e The Permittees will ensure that the Waste Processing Strategy required by Permit Condition III.3.B.7.a, provides for the immediate treatment or blending of waste accepted for management at the 200 Area ETF such that the resulting waste or mixture is no longer reactive or ignitable when further managed in 200 Area ETF tank systems. [WAC 173-303-640(9)]

III.3.P.2.f The Permittees will comply with the requirements of WAC 173-303-640(10), incorporated by reference.

III.3.Q SURFACE IMPOUNDMENTS

III.3.Q.1 The Permittees will maintain the three LERF basins according to the requirements of WAC 173-303-650 (2)(f), incorporated by reference.

III.3.Q.2 The Permittees will operate the LERF basins according to the requirements of Addendum C, Section C.5.3, and Addendum I, Section I.1.2.3.1~~I.2.2.3.1~~ to prevent over-topping. [WAC 173-303-650 (2)(c)]

III.3.Q.3 The Permittees will develop and maintain, and operate the LERF basins to ensure that any flow of waste into the impoundment can be immediately shut off in the event of overtopping or liner failure. [WAC 173-303-650 (2)(d)]

III.3.Q.4 The Permittees will comply with the requirements of WAC 173-303-650 (2)(g), incorporated by reference.

III.3.Q.5 The Permittees will comply with the requirements of WAC 173-303-650 (4)(b), incorporated by reference.

III.3.Q.6 The Permittees will comply with the requirements of WAC 173-303-650 (4)(c), incorporated by reference. The certification required by this Permit Condition must be provided to Ecology no later than seven calendar days after the date of the certification. A copy of the certification will be placed in the Hanford Facility Operating Record, LERF and 200 Area ETF file required by Permit Condition II.I.1. [WAC 173-303-650 (4)(c)]

III.3.Q.7 The Permittees will comply with the requirements of WAC 173-303-650(5)(b), incorporated by reference, in response to events in WAC 173-303-650(5)(a), incorporated by reference.

III.3.Q.8 The Permittees will comply with the requirements of WAC 173-303-650(5)(d) for any LERF basin that has been removed from service in accordance with Permit Condition III.3.Q.7 that the Permittees will restore to service. [WAC 173-303-650(5)(d)]

III.3.Q.9 The Permittees will close any LERF basin removed from service in accordance with the requirements of Permit Condition III.3.Q.7 or a basin that cannot be repaired or that the Permittees will not to return to service. [WAC 173-303-650(5)(e)]

III.3.Q.10 The Permittees will comply with the requirements of Addendum C, Section C.5.10 with respect to management of ignitable or reactive wastes in the LERF basins. [WAC 173-303-650(7)]

III.3.Q.11 The Permittees can place incompatible wastes and materials in the same LERF basin only if in compliance with the requirements of WAC 173-303-395(1)(b), (c). [WAC 173-303-650(8)]

III.3.Q.12 The Permittees will use the action leakage rate in Addendum C, Section C.5.8, for operation of LERF basins, and comply with the requirements of WAC 173-303-650(10)(b). [WAC 173-303-650(10)]

III.3.Q.13 The Permittees will comply with the requirements of WAC 173-303-650(11), incorporated by reference.

III.3.Q.14 The Permittees will comply with the requirements of 40 CFR 264, Subpart CC, incorporated by reference by WAC 173-303-692.

III.3.R GROUNDWATER

III.3.R.1 The Permittees will comply with the requirements of Addendum D, Groundwater Monitoring Plan. [WAC 173-303-645]

III.3.R.2 All wells constructed pursuant to this Permit will be constructed in compliance with Chapter 173-160 WAC incorporated by reference through WAC 173-303-645 (8)(c).

III.3.R.3 Update the Groundwater Monitoring Network

III.3.R.3.a The Permittees will install an additional downgradient monitoring well E-26-15 as identified in Addendum D, Groundwater Monitoring Plan by December, 2016.

III.3.R.3.b Within 60-days of the well installation, the Permittees will submit a Class 2 Permit modification [WAC 173-303-830 Appendix I, C.1.a] to update Addendum D and include the additional monitoring well into the groundwater monitoring network.

III.3.R.3.c Concurrently with the permit modification request, the Permittees will submit a revised "Liquid Effluent Retention Facility Characterization Report" for the additional monitoring well that includes:

1) Well construction in accordance with WAC 173-303-645(8)(c)

2) Well screen placement in the upper aquifer in accordance with WAC 173-303-645(8)(a)
3) Hydrogeologic conditions, stratigraphy and hydraulic conductivity, derived from geologist observations of borehole archive samples, down hole gamma logging, and aquifer slug tests in accordance with WAC 173-303-645(8)(a)(i)(A)
4) Drilling and sampling details in accordance with WAC 173-303-645(8)(d)
5) Borehole corrections (e.g., precision surveys, gyroscopic corrections, and barometric response corrections) to ensure adequate hydraulic understanding considering the very small gradient in accordance with WAC 173-303-645(8)(f)
6) Geochemical comparison of the water quality with other existing wells to ensure anticipated representative conditions in accordance with WAC 173-303-645(8)(a)(ii)
7) Document surface location as required by WAC 173-303-645(6)

III.3.R.3.c.1 Groundwater sample results from the new well (E-26-15) and the existing wells for all constituents in the Addendum D, Groundwater Monitoring Plan for the Liquid Effluent Retention Facility,

III.3.R.3.c.2 Results of evaluating final well development data and drilling logs,

III.3.R.3.c.2.a A well use designation (e.g., upgradient or downgradient).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Addendum A
Part A Form

Date Received Month Day Year	Reviewed by: ER Skwarek	Date: 03/31/2015
	Approved by: PK Skwarek for Suzanne Dahl	Date: 03/31/2015

I. This form is submitted to: (place an "X" in the appropriate box)

☒	Request modification to a final status permit (commonly called a "Part B" permit)	
☐	Request a change under interim status	
☐	Apply for a final status permit. This includes the application for the initial final status permit for a site or for a permit renewal (i.e., a new permit to replace an expiring permit).	
☐	Establish interim status because of the wastes newly regulated on:	(Date)
	List waste codes:	

II. EPA/State ID Number

W	A	7	8	9	0	0	0	8	9	6	7

III. Name of Facility

U.S. Department of Energy – Hanford Facility

IV. Facility Location (Physical address not P.O. Box or Route Number)

A. Street

Refer to Permit Attachment 2, Hanford Facility Permit Legal Description ~~825 Jadwin~~

City or Town	State	ZIP Code
Near Richland	WA	~~99352~~

County Code	County Name
005	Benton

B. Land Type	C. Geographic Location Latitude (degrees, mins, secs)	Longitude (degrees, mins, secs)	D. Facility Existence Date Month Day Year
F	Refer to TOPO Map (Section XV.)		~~10~~ ~~13~~ ~~10~~ ~~92~~ 1984 ~~03~~

V. Facility Mailing Address

Street or P.O. Box

P.O. Box 450

City or Town	State	ZIP Code
Richland	WA	99352

VI. Facility contact (Person to be contacted regarding waste activities at facility)		
Name (last)	**(first)**	
Smith	Kevin	
Job Title	**Phone Number (area code and number)**	
Manager	(509) 372-2315	
Contact Address		
Street or P.O. Box		
P.O. Box 450		
City or Town	**State**	**ZIP Code**
Richland	WA	99352

VII. Facility Operator Information	
A. Name	**Phone Number**
Department of Energy Owner/Operator Washington River Protection Solutions, LLC Co-Operator for dangerous waste management units in LERF & 200 Area ETF*	(509) 372-2315 (509) 372-~~99749138~~*
Street or P.O. Box	
P.O. Box 450 P.O. Box 850*	

City or Town	State	ZIP Code
Richland	WA	99352

B. Operator Type	F									
C. Does the name in VII.A reflect a proposed change in operator?	☐ Yes ☒ No ~~Co-Operator* change~~									
If yes, provide the scheduled date for the change:	**Month**		**Day**			**Year**				
	~~0~~	~~3~~	~~3~~	~~0~~		~~2~~	~~0~~	~~1~~	~~5~~	
D. Is the name listed in VII.A. also the owner? If yes, skip to Section VIII.C.	☐ Yes ☒ No									

VIII. Facility Owner Information	
A. Name	**Phone Number (area code and number)**
~~Kevin W. Smith,~~ U.S. Department of Energy~~Facility Property Owner~~	(509) 372-2315
Street or P.O. Box	
P.O. Box 450	

City or Town	State	ZIP Code
Richland	WA	99352

B. Owner Type	F									
C. Does the name in VIII.A reflect a proposed change in owner?	☐ Yes ☒ No									
If yes, provide the scheduled date for the change:	**Month**		**Day**			**Year**				

IX. NAICS Codes (5/6 digit codes)													
A. First							**B. Second**						
5	6	2	2	1	1	Waste Treatment & Disposal	~~9~~	~~2~~	~~4~~	~~1~~	~~1~~	~~0~~	~~Administration of Air & Water Resource & Solid Waste Management Programs~~
C. Third							**D. Fourth**						
~~5~~	~~4~~	~~1~~	~~7~~	~~1~~		~~Research & Development in the Physical, Engineering, & Life Sciences~~							

X. Other Environmental Permits (see instructions)

A. Permit Type	B. Permit Number	C. Description
E	AOP00-0506	Title V Air Operating Permit
~~E~~	~~FF-01-14-6~~	~~WAC 246-247 Radioactive Air Emissions approval, LERF Basin 44, EU 146, AIR 12-305~~
~~E~~	~~FF-01-14-7~~	~~WAC 246-247 Radioactive Air Emissions approval, LERF Basin 43, EU 147, AIR 12-305~~
~~E~~	~~FF-01-14-8~~	~~WAC 246-247 Radioactive Air Emissions approval, LERF Basin 42, EU 148, AIR 12-305~~
~~E~~	~~FF-01-30-1~~	~~WAC 246-247 Radioactive Air Emissions approval, ETF, EU 301, AIR 12-305~~
~~E~~	~~DE07NWP-00033~~	~~WAC 173-400 & 460 Criteria & Toxics approval~~
E	DELISTING	ETF Delisting, 70 Federal Register (FR) 44496, dated August 3, 2005
E	TSCA03-10-00-22	Toxic Substance Control Act (TSCA) Risk-based Disposal approval~~,40 CFR 761~~ (RBDA) Application for Management of Polychlorinated Biphenyl (PCB) Remediation Waste at the 200 Area Liquid Waste Processing Facilities, dated June 8, 2004
E	OAWT-107	Approval of the Request for Approval of Alternate Reuse Practices for the 200 Area Effluent Treatment Facility (ETF) Treated Effluent, 05-AMCP-0378, dated August 3, 2005
~~U~~ E	ST0004500	WAC 173-216, State Waste Discharge Permit for the 200 Area Effluent Treatment Facility State-Approved Land Disposal Site
~~U~~ E	ST0004511	WAC 173-216, State Waste Discharge Permit Program, Sitewide Permit for ~~m~~Miscellaneous ~~s~~Streams
~~E~~	~~WC-M-12-7~~	~~40 CFR 761.61(c), TSCA risk-based approval 2003-10-22~~

XI. Nature of Business (provide a brief description that includes both dangerous waste and non-dangerous waste areas and activities)

Construction of the Liquid Effluent Retention Facility (LERF) began in 1990. Waste management operations began at LERF in April 1994. Construction of the 200 Area Effluent Treatment Facility (ETF) began in 1992. Waste management operations began at the 200 Area ETF in November of 1995.

The LERF and 200 Area ETF comprise an aqueous waste treatment system located in the 200 East Area that provides storage and treatment for a variety of aqueous mixed waste. This aqueous waste includes process condensate from the 242-A Evaporator and other aqueous waste generated from onsite remediation and waste management activities.

The LERF consists of three lined surface impoundments, or basins. Aqueous waste from LERF is pumped to the 200 Area ETF for treatment in a series of process units, or systems, that remove or destroy dangerous waste constituents. The treated effluent is discharged to a State-Approved Land Disposal Site (SALDS) north of the 200 West Area, under the authority of a Washington State Waste Discharge Permit (ST0004500) and the 200 Area Final Delisting (40 CFR-261, Appendix IX, Table 2)

Sludge that accumulates in the bottoms of 200 Area ETF process tanks is removed periodically and placed into containers. The waste is solidified by decanting the supernate from the container and the remainder of the liquid is allowed to evaporate, or absorbents are added, as necessary, to address the residual liquid. The process design capacity for treatment of waste in containers (T04) is ~~18,927 liters per day~~ listed in Section XII.

EXAMPLE FOR COMPLETING ITEMS XII and XIII (shown in lines numbered X-1, X-2, and X-3 below): A facility has two storage tanks that hold 1200 gallons and 400 gallons respectively. There is also treatment in tanks at 20 gallons/hr. Finally, a one-quarter acre area that is two meters deep will undergo in situ *vitrification*.

Section XII. Process Codes and Design Capacities								Section XIII. Other Process Codes								
Line Number		A. Process Codes (enter code)			B. Process Design Capacity		C. Process Total Number of Units	Line Number		A. Process Codes (enter code)			B. Process Design Capacity		C. Process Total Number of Units	D. Process Description
					1. Amount	2. Unit of Measure (enter code)							1. Amount	2. Unit of Measure (enter code)		
X	1	S	0	2	1,600	G	002	X	1	T	0	4	700	C	001	In situ vitrification
X	2	T	0	3	20	E	001									
X	3	T	0	4	700	C	001									
	1	S	0	4	88,500,000	L	003		1	T	0	4	18,927	V	001	container treatment
	2	T	0	2	88,500,000	V	003		2							
	3	S	0	2	9,849,350	L	019		3							
	4	T	0	1	817,646	V	019		4							
	5	S	0	1	147,630	L	003		5							
	6	T	0	4	18,927	V	001		6							
	7								7							
	8								8							
	9								9							
1	0							1	0							
1	1							1	1							
1	2							1	2							
1	3							1	3							
1	4							1	4							
1	5							1	5							
1	6							1	6							
1	7							1	7							
1	8							1	8							
1	9							1	9							
2	0							2	0							
2	1							2	1							
2	2							2	2							
2	3							2	3							
2	4							2	4							
2	5							2	5							

XIV. Description of Dangerous Wastes

Example for completing this section: A facility will receive three non-listed wastes, then store and treat them on-site. Two wastes are corrosive only, with the facility receiving and storing the wastes in containers. There will be about 200 pounds per year of each of these two wastes, which will be neutralized in a tank. The other waste is corrosive and ignitable and will be neutralized then blended into hazardous waste fuel. There will be about 100 pounds per year of that waste, which will be received in bulk and put into tanks.

Line Number	A. Dangerous Waste No. (enter code)	B. Estimated Annual Quantity of Waste	C. Unit of Measure (enter code)	D. Processes (1) Process Codes (enter)	D. Processes (2) Process Description [If a code is not entered in D (1)]
X 1	D 0 0 2	400	P	S 0 1 T 0 1	
X 2	D 0 0 1	100	P	S 0 2 T 0 1	
X 3	D 0 0 2				Included with above
1	D 0 0 1	106,940,410	K	S 0 4 T 0 2 0 0 0	
2	D 0 0 2		K	S 0 ~~2~~ 4 T 0 ~~1~~ 2 0 0 0	Included with above
3	D 0 0 3		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
4	D 0 0 4		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
5	D 0 0 5		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
6	D 0 0 6		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
7	D 0 0 7		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
8	D 0 0 8		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
9	D 0 0 9		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
10	D 0 1 0		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
11	D 0 1 1		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
12	D 0 1 8		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
13	D 0 1 9		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
14	D 0 2 2		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
15	D 0 2 8		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
16	D 0 2 9		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
17	D 0 3 0		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
18	D 0 3 3		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
19	D 0 3 4		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
20	D 0 3 5		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
21	D 0 3 6		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
22	D 0 3 8		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
23	D 0 3 9		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
24	D 0 4 0		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above
25	D 0 4 1		~~K~~	~~S~~ ~~0~~ 4 ~~T~~ ~~0~~ ~~2~~	Included with above

EPA/State ID Number	W	A	7	8	9	0	0	0	8	9	6	7

Continuation of Section XIV. Description of Dangerous Waste

Line Number	A. Dangerous Waste No. (enter code)				B. Estimated Annual Quantity of Waste	C. Unit of Measure (enter code)	D. Process									
							(1) Process Codes (enter)									(2) Process Description [If a code is not entered in D (1)]
26	D	0	4	3		K	S	0	4	T	0	2				Included with above
27	F	0	0	1		K	S	0	4	T	0	2				Included with above
28	F	0	0	2		K	S	0	4	T	0	2				Included with above
29	F	0	0	3		K	S	0	4	T	0	2				Included with above
30	F	0	0	4		K	S	0	4	T	0	2				Included with above
31	F	0	0	5		K	S	0	4	T	0	2				Included with above
32	F	0	3	9		K	S	0	4	T	0	2				Included with above
33	W	T	0	1		K	S	0	4	T	0	2				Included with above
34	W	T	0	2		K	S	0	4	T	0	2				Included with above
35	U	2	1	0		K	S	0	4	T	0	2				Included with above
36	D	0	0	1	106,940,410	K	T	0	1							
37	D	0	0	2		K	T	0	1							
38	D	0	0	3		K	T	0	1							
39	D	0	0	4		K	T	0	1							
40	D	0	0	5		K	T	0	1							
41	D	0	0	6		K	T	0	1							
42	D	0	0	7		K	T	0	1							
43	D	0	0	8		K	T	0	1							
44	D	0	0	9		K	T	0	1							
45	D	0	1	0		K	T	0	1							
46	D	0	1	1		K	T	0	1							
47	D	0	1	8		K	T	0	1							
48	D	0	1	9		K	T	0	1							
49	D	0	2	2		K	T	0	1							
50	D	0	2	8		K	T	0	1							
51	D	0	2	9		K	T	0	1							
52	D	0	3	0		K	T	0	1							
53	D	0	3	3		K	T	0	1							
54	D	0	3	4		K	T	0	1							
55	D	0	3	5		K	T	0	1							
56	D	0	3	6		K	T	0	1							
57	D	0	3	8		K	T	0	1							

EPA/State ID Number	W	A	7	8	9	0	0	0	8	9	6	7

Continuation of Section XIV. Description of Dangerous Waste

| Line Number | A. Dangerous Waste No. (enter code) | | | | B. Estimated Annual Quantity of Waste | C. Unit of Measure (enter code) | D. Process | | | |

EPA/State ID Number	W	A	7	8	9	0	0	0	8	9	6	7

Continuation of Section XIV. Description of Dangerous Waste

| Line Number | A. Dangerous Waste No. (enter code) | | | | B. Estimated Annual Quantity of Waste | C. Unit of Measure (enter code) | D. Process | | | |

EPA/State ID Number	W	A	7	8	9	0	0	0	8	9	6	7

Continuation of Section XIV. Description of Dangerous Waste

Line Number	A. Dangerous Waste No. (enter code)				B. Estimated Annual Quantity of Waste	C. Unit of Measure (enter code)	D. Process									
							(1) Process Codes (enter)									(2) Process Description [If a code is not entered in D (1)]
~~11~~747	D	0	1	8		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~11~~848	D	0	1	9		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~11~~949	D	0	2	2		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~050	D	0	2	8		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~151	D	0	2	9		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~252	D	0	3	0		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~353	D	0	3	3		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~454	D	0	3	4		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~555	D	0	3	5		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~656	D	0	3	6		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~757	D	0	3	8		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~858	D	0	3	9		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~12~~959	D	0	4	0		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~13~~060	D	0	4	1		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~13~~161	D	0	4	3		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~13~~262	F	0	0	1		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~13~~363	F	0	0	2		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~13~~464	F	0	0	3		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~13~~565	F	0	0	4		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~13~~666	F	0	0	5		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~
~~13~~767	F	0	3	9		~~K~~	~~S~~	~~0~~	~~1~~							Included with above~~Includes Debris~~

EPA/State ID Number	W	A	7	8	9	0	0	0	8	9	6	7

Continuation of Section XIV. Description of Dangerous Waste

Line Number	A. Dangerous Waste No. (enter code)				B. Estimated Annual Quantity of Waste	C. Unit of Measure (enter code)	D. Process								
							(1) Process Codes (enter)								(2) Process Description [If a code is not entered in D (1)]
~~13868~~	W	T	0	1		~~K~~	~~S~~	~~0~~	~~1~~						Included with above~~Includes Debris~~
~~13969~~	W	T	0	2		~~K~~	~~S~~	~~0~~	~~1~~						Included with above~~Includes Debris~~
~~14070~~	U	2	1	0		~~K~~	~~S~~	~~0~~	~~1~~						Included with above~~Includes Debris~~
~~14171~~	D	0	0	1	81,310	K	T	0	4						Includes Debris
~~14272~~	D	0	0	2		~~K~~	~~T~~	~~0~~	~~4~~						Included with above~~Includes Debris~~
~~14373~~	D	0	0	3		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~14474~~	D	0	0	4		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~14575~~	D	0	0	5		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~14676~~	D	0	0	6		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~14777~~	D	0	0	7		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~14878~~	D	0	0	8		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~14979~~	D	0	0	9		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15080~~	D	0	1	0		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15181~~	D	0	1	1		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15282~~	D	0	1	8		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15383~~	D	0	1	9		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15484~~	D	0	2	2		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15585~~	D	0	2	8		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15686~~	D	0	2	9		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15787~~	D	0	3	0		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~

EPA/State ID Number	W	A	7	8	9	0	0	0	8	9	6	7

Continuation of Section XIV. Description of Dangerous Waste

Line Number	A. Dangerous Waste No. (enter code)				B. Estimated Annual Quantity of Waste	C. Unit of Measure (enter code)	D. Process								
							(1) Process Codes (enter)								(2) Process Description [If a code is not entered in D (1)]
~~15~~888	D	0	3	3		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~15~~989	D	0	3	4		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~090	D	0	3	5		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~191	D	0	3	6		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~292	D	0	3	8		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~393	D	0	3	9		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~494	D	0	4	0		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~595	D	0	4	1		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~696	D	0	4	3		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~797	F	0	0	1		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~898	F	0	0	2		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~16~~999	F	0	0	3		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~170~~100	F	0	0	4		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~171~~101	F	0	0	5		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~172~~102	F	0	3	9		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~173~~103	W	T	0	1		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~
~~174~~104	W	T	0	2		~~K~~	~~T~~	~~0~~	4						Included with above~~Includes Debris~~

EPA/State ID Number	W	A	7	8	9	0	0	0	8	9	6	7

Continuation of Section XIV. Description of Dangerous Waste

Line Number	A. Dangerous Waste No. (enter code)				B. Estimated Annual Quantity of Waste	C. Unit of Measure (enter code)	D. Process									
							(1) Process Codes (enter)									(2) Process Description [If a code is not entered in D (1)]
~~175~~105	U	2	1	0		~~K~~	~~T~~	~~0~~	4							Included with above~~Includes Debris~~
~~176~~106																
~~177~~107																
~~178~~108																
~~179~~109																
~~180~~110																
~~181~~111																
~~182~~																
~~183~~																

XV. Map

Attach to this application a topographic map of the area extending to at least one (1) mile beyond property boundaries. The map must show the outline of the facility; the location of each of its existing and proposed intake and discharge structures; each of its dangerous waste treatment, storage, recycling, or disposal units; and each well where fluids are injected underground. Include all springs, rivers, and other surface water bodies in this map area, plus drinking water wells listed in public records or otherwise known to the applicant within ¼ mile of the facility property boundary. The instructions provide additional information on meeting these requirements.

~~Topographic map is located in the Ecology Library~~

XVI. Facility Drawing

All existing facilities must include a scale drawing of the facility (refer to Instructions for more detail).

XVII. Photographs

All existing facilities must include photographs (aerial or ground-level) that clearly delineate all existing structures; existing storage, treatment, recycling, and disposal areas; and sites of future storage, treatment, recycling, or disposal areas (refer to Instructions for more detail).

XVIII. Certifications

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Operator Name and Official Title (type or print)	**Signature**	**Date Signed**
Kevin W. Smith, Manager U.S. Department of Energy Office of River Protection		1/15/15
Co-Operator* Name and Official Title (type or print) L. David Olson President and Project Manager Washington River Protection Solutions, LLC	**Signature** L David Olson	**Date Signed** 12/19/14
Co-Operator – Address and Telephone Number* P.O. Box 850 Richland, WA 99352 (509) 372-~~99749138~~		
Facility-Property Owner Name and Official Title (type or print) Kevin W. Smith, Manager U.S. Department of Energy Office of River Protection	**Signature**	**Date Signed** 1/15/15

Comments

~~Changes from Revision 3A to 4~~

~~Section V, "Facility Mailing Address"~~

- ~~Updated P.O. Box from 550 to 450.~~

~~Section VI, "Facility Contact"~~

- ~~Updated from "Matthew McCormick" to "Kevin Smith".~~
- ~~Updated phone number of facility contact.~~
- ~~Updated P.O. Box address of facility contact.~~

~~Section VII, "Facility Operator Information, A. Name"~~

- ~~Updated Owner/Operator phone number.~~
- ~~Updated Co-Operator name and phone number.~~
- ~~Updated P.O. Box addresses for Owner and Co-Operator.~~

~~Section VII, "Facility Operator Information, C"~~

- ~~Updated schedule for transition date to 03/30/2015.~~

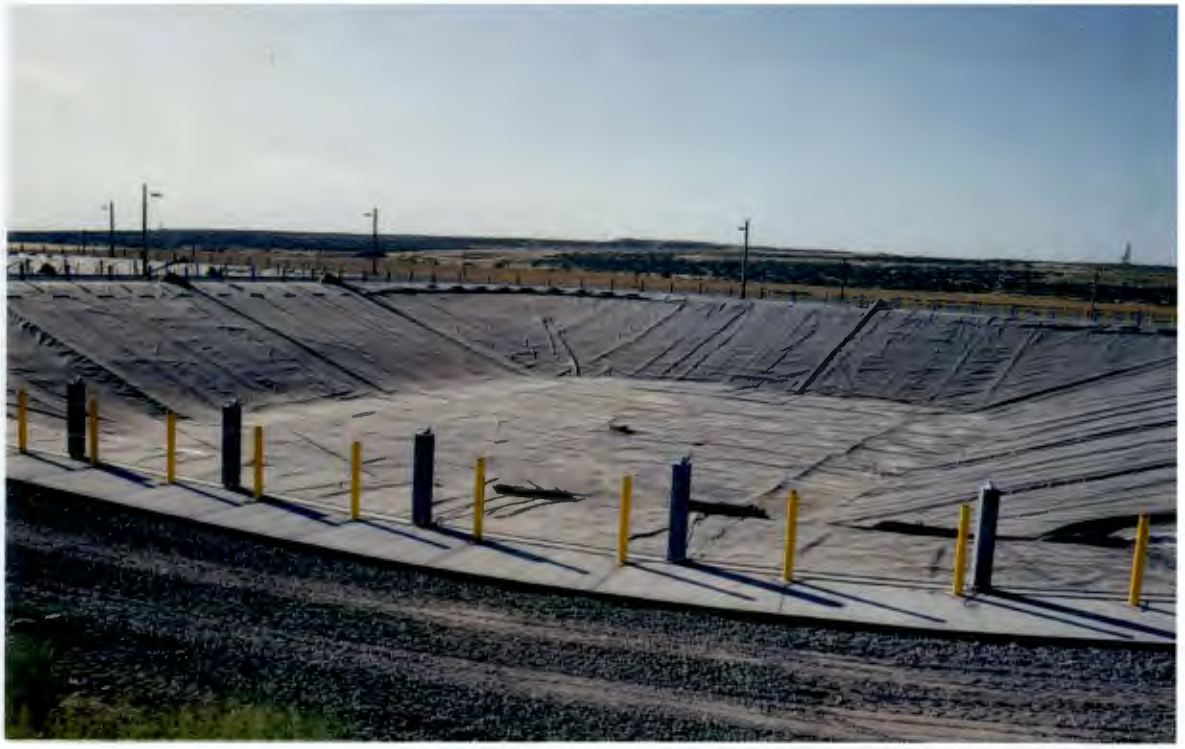
~~Section VIII, "Facility Owner Information, A. Name"~~

- ~~Updated from "Matthew S. McCormick" to "Kevin W. Smith".~~
- ~~Updated phone number of facility owner.~~
- ~~Updated PO Box address of facility owner.~~

~~Section XVIII, "Certifications"~~

- ~~Updated Operator from "Matthew S. McCormick" of "Richland Operations Office" to "Kevin W. Smith" of "Office of River Protection".~~
- ~~Updated Co-Operator from "John C. Fulton" of "CH2M Hill Plateau Remediation Company" to "L. David Olson" of Washington River Protection Solutions, LLC".~~
- ~~Updated Co-Operator title from "Chief Executive Officer" to "Project Manager".~~
- ~~Updated Co-Operator P.O. Box address and phone number.~~
- ~~Updated Facility Property Owner from "Matthew S. McCormick" of "Richland Operations Office" to "Kevin W. Smith" of "Office of River Protection".~~

Photo Taken 2/2010

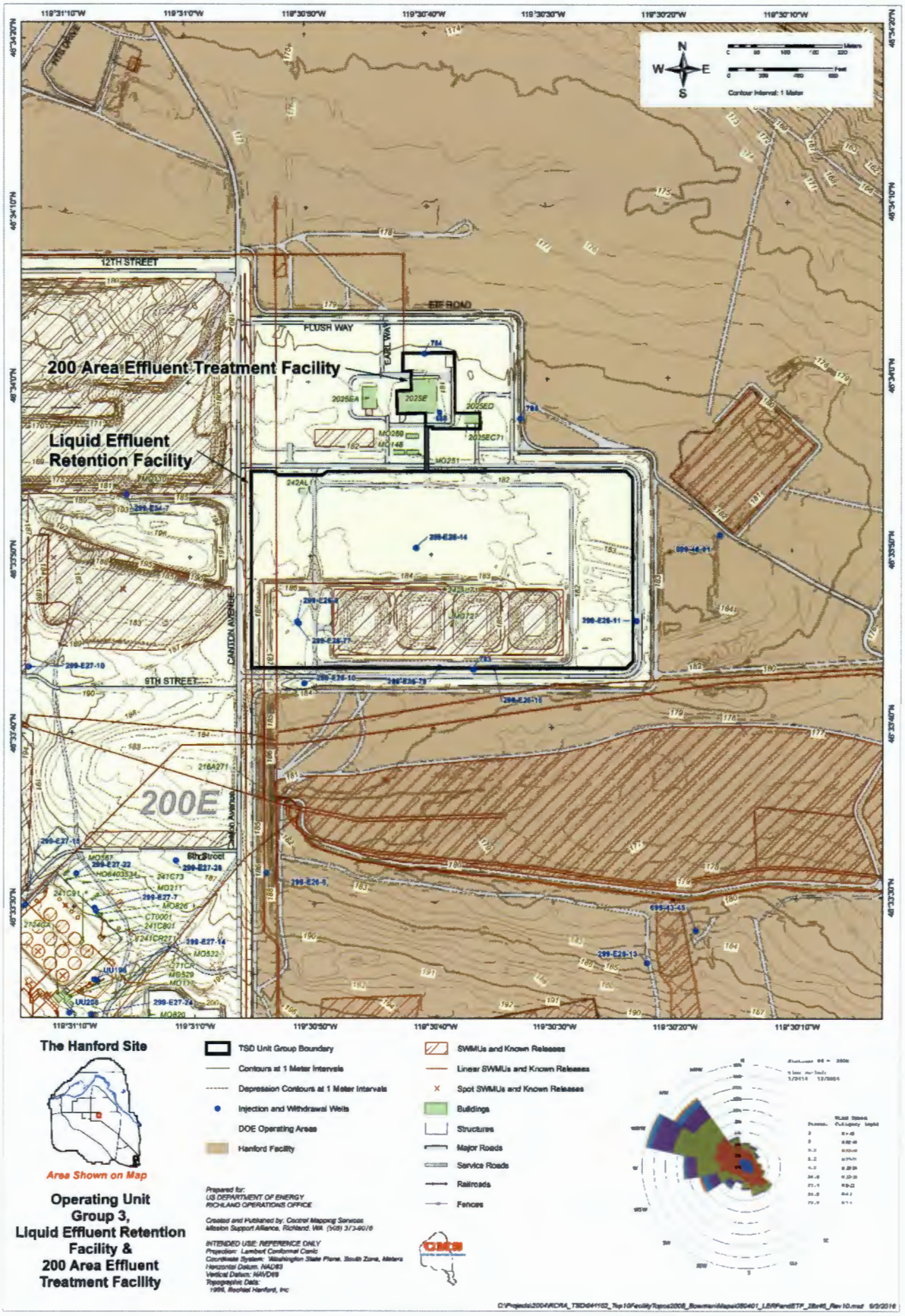


Typical Basin

Photo Taken 1992

~~Liquid Effluent Retention Facility~~
200 Area Effluent Treatment Facility

Photo Taken 2005


200 Area Effluent Treatment Facility
Liquid Effluent Retention Facility
12TH STREET
ETF ROAD
FLUSH WAY
EARL WAY
CANTON AVENUE
9TH STREET
200E
Contour Interval: 1 Meter
The Hanford Site
Area Shown on Map
Operating Unit Group 3, Liquid Effluent Retention Facility & 200 Area Effluent Treatment Facility
TSD Unit Group Boundary
Contours at 1 Meter Intervals
Depression Contours at 1 Meter Intervals
Injection and Withdrawal Wells
DOE Operating Areas
Hanford Facility
SWMUs and Known Releases
Linear SWMUs and Known Releases
Spot SWMUs and Known Releases
Buildings
Structures
Major Roads
Service Roads
Railroads
Fences
Prepared for:
US DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
Created and Published by: Central Mapping Services
Mission Support Alliance, Richland, WA (509) 373-9076
INTENDED USE: REFERENCE ONLY
Projection: Lambert Conformal Conic
Coordinate System: Washington State Plane, South Zone, Meters
Horizontal Datum: NAD83
Vertical Datum: NAVD88
Topographic Data:
1996, Bechtel Hanford, Inc

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ADDENDUM B
WASTE ANALYSIS PLAN

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ADDENDUM B
WASTE ANALYSIS PLAN

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Metric Conversion Chart

Into metric units			Out of metric units		
If you know	Multiply by	To get	If you know	Multiply by	To get
Length			Length		
inches	25.40	millimeters	millimeters	0.0393	inches
inches	2.54	centimeters	centimeters	0.393	inches
feet	0.3048	meters	meters	3.2808	feet
yards	0.914	meters	meters	1.09	yards
miles	1.609	kilometers	kilometers	0.62	miles
Area			Area		
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092	square meters	square meters	10.7639	square feet
square yards	0.836	square meters	square meters	1.20	square yards
square miles	2.59	square kilometers	square kilometers	0.39	square miles
acres	0.404	hectares	hectares	2.471	acres
Mass (weight)			Mass (weight)		
ounces	28.35	grams	grams	0.0352	ounces
pounds	0.453	kilograms	kilograms	2.2046	pounds
short ton	0.907	metric ton	metric ton	1.10	short ton
Volume			Volume		
fluid ounces	29.57	milliliters	milliliters	0.03	fluid ounces
quarts	0.95	liters	liters	1.057	quarts
gallons	3.79	liters	liters	0.26	gallons
cubic feet	0.03	cubic meters	cubic meters	35.3147	cubic feet
cubic yards	0.76456	cubic meters	cubic meters	1.308	cubic yards
Temperature			Temperature		
Fahrenheit	subtract 32 then multiply by 5/9ths	Celsius	Celsius	multiply by 9/5ths, then add 32	Fahrenheit
Force			Force		
pounds per square inch	6.895	kilopascals	kilopascals	1.4504×10^{-4}	pounds per square inch

Source: *Engineering Unit Conversions*, M. R. Lindeburg, P.E., Second Ed., 1990, Professional Publications, Inc., Belmont, California.

B. WASTE ANALYSIS PLAN

B.1 Introduction

In accordance with the regulations set forth in the Washington State Department of Ecology (Ecology) *Dangerous Waste Regulations*, Washington Administrative Code (WAC) 173-303-300, this waste analysis plan (WAP) has been prepared for operation of the Liquid Effluent Retention Facility (LERF) and the 200 Area Effluent Treatment Facility (200 Area ETF) located in the 200 East Area on the Hanford Site, Richland, Washington.

The purpose of this WAP is to ensure that adequate knowledge as defined in WAC 173-303-040, is obtained for dangerous and/or mixed waste accepted by and managed in LERF and 200 Area ETF. This WAP documents the sampling and analytical methods, and describes the procedures used to obtain this knowledge. This WAP also documents the requirements for generators sending aqueous waste to the LERF or 200 Area ETF for treatment. Throughout this WAP, the term generator includes any Hanford Site source, including treatment, storage, and disposal (TSD) units, whose process produces an aqueous waste.

LERF consists of three surface impoundments, which provide treatment and storage. The 200 Area ETF includes a tank system, which provides treatment and storage, and a container management area, which provides container storage and treatment. Additionally, this WAP discusses the sampling and analytical methods for the treated effluent (treated aqueous waste) that is discharged from 200 Area ETF as a non-dangerous, delisted waste to the State Approved Land Disposal Site (SALDS). Specifically, the WAP contains sampling and analysis requirements including quality assurance/quality control requirements, for the following:

- **Influent Waste Acceptance Process** - determines the acceptability of a particular aqueous waste at the LERF or 200 Area ETF pursuant to applicable Permit conditions, regulatory requirements, and operating capabilities prior to acceptance of the waste at the LERF or 200 Area ETF for treatment or storage. This includes documenting that wastes accepted for treatment at 200 Area ETF are within the treatability envelope required by the Final Delisting 200 Area ETF, Permit Condition-_1.a.i. Refer to Section B.2.
- **Special Management Requirements** - identifies the special management requirements for aqueous wastes managed in the LERF or 200 Area ETF. Refer to Section B.3.
- **Influent Aqueous Waste Sampling and Analysis** - describes influent sampling and analyses used to characterize an influent aqueous waste to ensure proper management of the waste and for compliance with the special management requirements. Also includes rationale for analyses. Refer to Section B.4.
- **Treated Effluent Sampling and Analysis** - describes sampling and analyses of treated effluent (i.e., treated aqueous waste) for compliance with ~~Washington State Waste Discharge Permit, No. ST 4500 (Ecology 2000)~~ Discharge Permit Number ST0004500; and Final Delisting 200 Area ETF [40 CFR 261, Appendix IX, Table 2 incorporated by reference by WAC 173-303-910(3) and the corresponding State Final Delisting issued pursuant to WAC 173-303-910(3) limits]. Also includes rationale for analyses. Refer to Section B.5.
- **200 Area ETF Generated Waste Sampling and Analysis** - describes the sampling and analyses used to characterize the secondary waste streams generated from the treatment process and to characterize waste generated from maintenance and operations activities. Also includes rationale for analyses. Characterization and designation of wastes generated from maintenance and operations activities are conducted pursuant to WAC 173-303-170 and are not subject to the permit requirements of WAC 173-303-800. These descriptions are included in this WAP for purposes of completeness, but are not enforceable conditions of this WAP or the permit. Refer to Section B.6.

- **Quality Assurance and Quality Control** - ensures the accuracy and precision of sampling and analysis activities. Refer to Section B.7.

This WAP meets the specific requirements of the following:

- Land Disposal Restrictions Treatment Exemption for the LERF under 40 CFR 268.4, U.S. Environmental Protection Agency (EPA), December 6, 1994 (EPA 1994).
- Final Delisting 200 Area ETF [40 CFR 261, Appendix IX, Table 2 incorporated by reference by WAC 173-303-910(3)].
- Corresponding State Final Delisting issued pursuant to WAC 173-303-910(3).
- Discharge Permit Number ST0004500~~Washington State Waste Discharge Permit (No. ST 4500)~~, as amended.
- Hanford Facility Dangerous Waste Permit (Permit) WA7890008967, as amended.

~~The~~ Some Permit ~~conditions~~ requirements from Discharge Permit Number ST0004500~~of the Washington State Waste Discharge Permit (No. ST 4500)~~ are included in this WAP for completeness.~~, as well as~~ In addition, generator requirements for designation of wastes generated by LERF and 200 Area ETF from operation and maintenance activities are also included in this WAP for completeness. The ~~Washington State Waste Discharge Permit (No. ST 4500)~~ Discharge Permit Number ST0004500 requirements~~Conditions~~ are not within the scope of RCRA or WAC 173-303 or subject to the permit requirements of WAC 173-303-800. Therefore, revisions of this WAP that are not governed by the requirements of WAC 173-303 will not be considered as a modification subject to review or approval by Ecology. Any other revisions to this WAP will be incorporated through the Permit modification process as necessary to demonstrate compliance with requirements of this Permit, including Permit Conditions I.E.7 and I.E.8.

B.1.1 Liquid Effluent Retention Facility and 200 Area Effluent Treatment Facility Description

The LERF and 200 Area ETF comprise an aqueous waste treatment system located in the 200 East Area. Both LERF and 200 Area ETF may receive aqueous waste through several inlets. 200 Area ETF can receive aqueous waste through three inlets. First, 200 Area ETF can receive aqueous waste directly from the LERF. Second, aqueous waste can be transferred from the 2025-ED Load-~~i~~In Station to 200 Area ETF. Third, aqueous waste can be transferred from containers (e.g., carboys, drums) to the 200 Area ETF through either the Secondary Waste Receiving Tanks or the Concentrate Tanks. The Load-~~i~~In Station is located just east of ~~200 Area ETF~~ building 2025-E and currently consists of three storage tanks and a pipeline that connects to either LERF or 200 Area ETF through fiberglass pipelines with secondary containment.

The LERF can receive aqueous waste through four inlets. First, aqueous waste can be transferred to LERF through a dedicated pipeline from the 200 West Area. Second, aqueous waste can be transferred through a pipeline that connects LERF with the 242-A Evaporator. Third, aqueous waste also can be transferred to LERF from a pipeline that connects LERF to the Load-~~i~~In Station ~~at 200 Area ETF~~. Finally, aqueous waste can be transferred into LERF through a series of sample ports located at each basin.

The LERF consists of three lined surface impoundments with a nominal capacity of 29.5 million liters each. Aqueous waste from LERF is pumped to 200 Area ETF through a double walled fiberglass pipeline. The pipeline is equipped with leak detection located in the annulus between the inner and outer pipes. Each basin is equipped with six available sample risers constructed of 15.2-centimeter (6-inch)-perforated pipe. A seventh sample riser in each basin is dedicated to influent waste receipt piping, and an eighth riser in each basin contains liquid level instrumentation. Each riser extends along the sides of each basin from the top to the bottom of the basin. Detailed information on the construction and operation of the LERF is provided in Addendum C, Process Information.

200 Area ETF is designed to treat the contaminants anticipated in process condensate from the 242-A Evaporator and other aqueous wastes from the Hanford Site. Section B.1.2 provides more information on the sources of these wastes.

The capabilities of 200 Area ETF were confirmed through pilot plant testing. A pilot plant was used to test surrogate solutions that contained constituents of concern anticipated in aqueous wastes on the Hanford Site. The pilot plant testing served as the basis for a demonstration of the treatment capabilities of 200 Area ETF in the *200 Area Effluent Treatment Facility Delisting Petition* (DOE/RL-92-72).

200 Area ETF consists of a primary and a secondary treatment train (Figure C.4 and C.5~~B.1~~). The primary treatment train removes or destroys dangerous and mixed waste components from the aqueous waste. In the secondary treatment train, the waste components are concentrated and dried into a powder. This waste is containerized, and transferred to a waste treatment, storage, and/or disposal (TSD) unit.

Each treatment train consists of a series of operations. The primary treatment train includes the following:

- surge tank
- Filtration
- Ultraviolet light oxidation (UV/OX)
- pH adjustment
- Hydrogen peroxide decomposition
- Degasification
- Reverse osmosis (RO)
- Ion exchange
- Final pH adjustment and verification

The secondary treatment train uses the following:

- Secondary waste receiving
- Evaporation (with mechanical vapor recompression)
- Concentrate staging
- Thin film drying
- Container handling
- Supporting systems

A dry powder waste is generated from the secondary treatment train, from the treatment of an aqueous waste. The secondary waste treatment system typically receives and processes by-products generated from the primary treatment train. However, in an alternate operating scenario, some aqueous wastes may be fed to the secondary treatment train before the primary treatment train.

The treated effluent is contained in verification tanks where the effluent is sampled to confirm that the effluent meets the delisting criteria. Under 40 CFR 261, Appendix IX, Table 2 incorporated by reference by WAC 173-303-910(3), the treated effluent from 200 Area ETF is considered a delisted waste; that is, the treated effluent is no longer a listed dangerous waste subject to the hazardous waste management requirements of RCRA provided that the delisting criteria are satisfied and the treated effluent does not exhibit a dangerous characteristic. The treated effluent is discharged under the Discharge Permit Number ST0004500 ~~Washington State Waste Discharge Permit (No. ST 4500)~~ as a nondangerous, delisted waste to the SALDS, located in the 600 Area, north of the 200 West Area. A portion of the treated wastewater from the Verification Tanks is recycled as service water throughout the facility; for

example, it is used to dilute bulk acid and caustic to meet processing needs, thereby reducing the demand for process water.

B.1.2 Sources of Aqueous Waste

200 Area ETF was intended and designed to treat a variety of mixed wastes. However, process condensate from the 242-A Evaporator was the only mixed waste initially identified for storage and treatment in the LERF and 200 Area ETF. As cleanup activities at Hanford progress, many of the aqueous wastes generated from site remediation and waste management activities are sent to the LERF and 200 Area ETF for treatment and storage. A brief discussion of waste streams that may be managed by LERF and 200 Area ETF in the future may be found in the 200 Area ETF Delisting Petition (~~DOE/RL-92-97~~ DOE/RL-92-72). Prior to management of any new waste streams, it may be necessary to modify this WAP through the permit modification process to ensure that adequate knowledge of such new waste streams is available prior to management of them in LERF and 200 Area ETF.

The 242-A process condensate is a dangerous waste because it is derived from a listed, dangerous waste stored in the Double-Shell Tank (DST) System. The DST waste is transferred to the 242-A Evaporator where the waste is concentrated through an evaporation process. The concentrated slurry waste is returned to the DST System, and the evaporated portion of the waste is recondensed, collected, and transferred as process condensate to the LERF.

Other aqueous wastes that are treated and stored at the LERF and 200 Area ETF include, but are not limited to the following Hanford wastes:

- Contaminated groundwater from pump-and-treat remediation activities such as groundwater from the 200-UP-1 Operable Unit;
- Purgewater from groundwater monitoring activities;
- Water from deactivation activities, such as water from the spent fuel storage basins at deactivated reactors (e.g., N Reactor);
- Laboratory aqueous waste from unused samples and sample analyses;
- Leachate from landfills, such as the Environmental Restoration Disposal Facility;
- Any dilute waste, which may be accepted for treatment and within the scope of wastewaters that maybe delisted under terms of the revised delisting (40 CFR 261, Appendix IX, Table 2 incorporated by reference by WAC 173-303-910(3)).

Most of these aqueous wastes are accumulated in batches in a LERF basin for interim storage and treatment through pH and flow equalization before final treatment in 200 Area ETF. However, some aqueous wastes, such as 200-UP-1 Groundwater, maybe treated on a flow through basis in LERF en route to 200 Area ETF for final treatment. The constituents in these aqueous wastes are common to the Hanford Site and were considered in pilot plant testing or in vendor tests, either as a constituent or as a family of constituents. According to the Final Delisting 200 Area ETF, and Permit Condition- III.3.B.7~~1.a.i~~, all wastes accepted for treatment at 200 Area ETF must be within a specified treatability envelope that ensures that wastes will be within the treatment capability of 200 Area ETF.

B.2 Influent Waste Acceptance Process

Throughout the acceptance process, there are specific criteria required for an influent waste (i.e., aqueous waste) to be accepted at the LERF and/or 200 Area ETF. These criteria are identified in the following sections and summarized in Table B.2. The process of accepting a waste into the LERF and 200 Area ETF systems involves a series of steps, as follows.

- **Waste information**: The generator of an aqueous waste works with LERF and 200 Area ETF personnel to provide characterization data of the waste stream (Section B.2.1).

- **Waste management decision process**: LERF and 200 Area ETF management decision is based on a case-by-case evaluation of whether an aqueous waste stream is acceptable for treatment or storage at LERF and the 200 Area ETF. The evaluation has two categories:
  - **Regulatory acceptability:** a review to determine if there are any, regulatory concerns that would prohibit the storage or treatment of an aqueous waste in the LERF or 200 Area ETF; e.g., treatment would meet permit conditions that would comply with applicable regulations.
  - **Operational acceptability:** an evaluation to determine if there are any operational concerns that would prohibit the storage or treatment of an aqueous waste in the LERF or 200 Area ETF and storage of treatment residuals; e.g., determine treatability and compatibility or safety considerations (Section B.2.2.2).

B.2.1 Waste Information

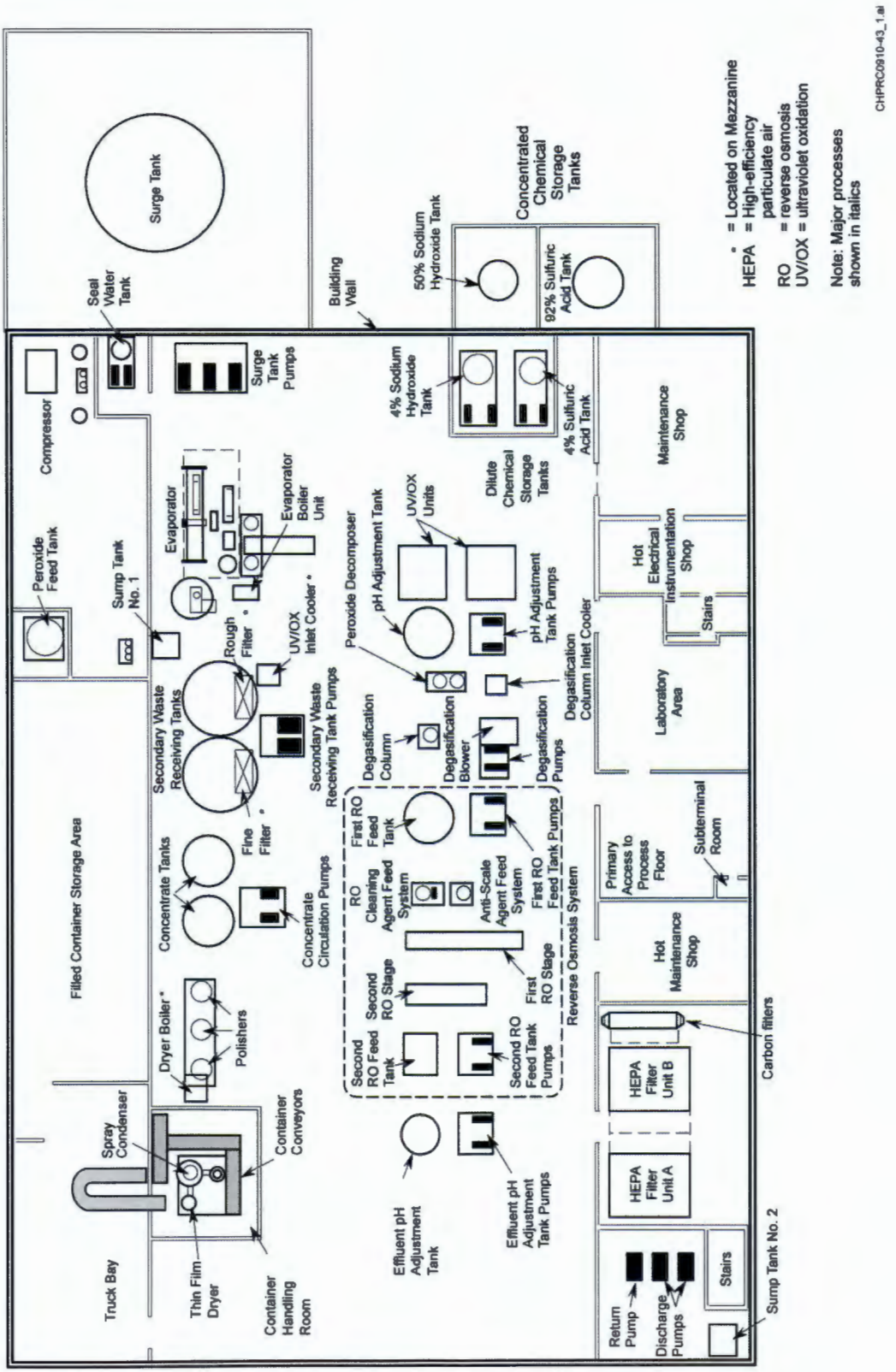
When an aqueous waste stream is identified for treatment or storage in the LERF or 200 Area ETF, the generator is required to characterize the waste stream according to the requirements in Section B.2.1.1 and document the results of characterization on an aqueous waste profile sheet. This requirement is the first waste acceptance criterion. The LERF and 200 Area ETF personnel work with the generators to ensure that the necessary information is collected for the characterization of a waste stream (i.e., the appropriate analyses or adequate knowledge), and that the information provided on the waste profile sheet is complete. The completed waste profile sheet is maintained in the Hanford Facility Operating Record, LERF and 200 Area ETF File according to Permit Condition II.I.1.j.

B.2.1.1 Waste Characterization

Because the constituents in the individual aqueous waste streams vary, each waste stream is characterized and evaluated for acceptability on a case-by-case basis. The generator is required to designate an aqueous waste, which generally will be based on analytical data. However, a generator may use knowledge to substantiate the waste designation, or for general characterization information. Examples of acceptable knowledge include the following:

- Documented data or information on processes similar to that which generated the aqueous waste stream
- Information/documentation that the waste stream is from specific, well documented processes, e.g., F-listed wastes
- Information/documentation that sampling/analyzing a waste stream would pose health and safety risks to personnel
- Information/documentation that the waste stream does not lend itself to collecting a laboratory sample for example, wastewater collected (e.g., sump, tank) where the source water characterization is documented. Typically, these circumstances occur at decommissioned buildings or locations, not at operating units.

When a generator performs characterization of a dangerous and/or mixed waste stream based on knowledge, LERF and 200 Area ETF personnel review the knowledge as part of the waste acceptance process to ensure the knowledge satisfies the definition of *knowledge* in WAC 173-303-040. Specifically, LERF and 200 Area ETF personnel review the generator's processes to verify the integrity of the knowledge, and determine whether the knowledge is current and consistent with requirements of this ~~is~~ WAP. LERF and 200 Area ETF management or their designee determines the final decision on the adequacy of the knowledge. The persons reviewing generator process knowledge and those making decisions on the adequacy of knowledge are trained according to the requirements of Addendum G, Personnel Training.



~~Figure B.1. 200 Area Effluent Treatment Facility Floor Plan~~

The generator is also responsible for identifying Land Disposal Restrictions (LDRs) treatment standards applicable to the influent aqueous waste as part of the characterization, as required under 40 CFR 268.40 incorporated by reference by WAC 173-303-140. Because the 200 Area ETF main treatment train is a Clean Water Act, equivalent treatment unit [40 CFR 268.37(a)] incorporated by reference by WAC 173-303-140, generators are not required to identify underlying hazardous constituents for characteristic wastes pursuant to 40 CFR 268.9, incorporated by reference by WAC 173-303-140, for wastewaters (i.e., <1 percent total suspended solids and <1 percent total organic carbon). The 200 Area ETF secondary waste (e.g., powder) reflects a change in LDR treatability group (i.e., wastewater to non-wastewater) so there is a new LDR point of generation, at which point any characteristic and associated underlying hazardous constituents must be identified. Therefore, generators of a non-wastewater may be required to identify underlying hazardous constituents for characteristic wastes pursuant to 40 CFR 268.9, incorporated by reference by WAC 173-303-140.

When analyzing an aqueous waste stream for LERF and 200 Area ETF waste acceptance characterization, a generator is required to use the target list of parameters identified in Table B.3, of this WAP. This requirement is in addition to any analysis required for purposes of designation under WAC 173-303-070. These data are used by LERF and 200 Area ETF to verify the treatability of an aqueous waste stream, and to develop a treatment plan for the waste after acceptance. Refer to Table B.6, for the corresponding analytical methods. The generator may use knowledge in lieu of some analyses, as determined by LERF and 200 Area ETF management or their designee, if the knowledge satisfies the definition of *knowledge* in WAC 173-303-040. For example if a generator provides information that the process generating an aqueous waste does not include or involve organic chemicals, analyses for organic compounds likely would not be required. Additional analyses could be required if historical information and/or knowledge indicate that an aqueous waste contains constituents not included in the target list of parameters.

The characterization and historical information are documented in the waste profile sheet, which is discussed in the following section and is part of the Hanford Facility Operating Record, LERF and 200 Area ETF File according to Permit Condition II.I.

B.2.1.2 Aqueous Waste Profile Sheet

The waste profile sheet documents the characterization of each new aqueous waste stream. The profile includes a detailed description of the source, volume, waste designation and applicable LDR treatment standards, and physical nature (wastewater or non-wastewater) of the aqueous waste. For an aqueous waste to be accepted for treatment or storage in the LERF or 200 Area ETF, each new waste stream generator is required to complete and provide this form to LERF and 200 Area ETF management. Each generator also is required to provide the analytical data and/or knowledge used to designate the aqueous waste stream according to WAC 173-303-070 and to determine the chemical and physical nature of the waste.

The LERF and 200 Area ETF management determine whether the information on the waste profile sheet is sufficient according to the criteria above. The LERF and 200 Area ETF management use this information to evaluate the acceptability of the aqueous waste stream for storage and treatment in the LERF and 200 Area ETF, and to determine if the secondary waste generated from treatment is acceptable for storage at the 200 Area ETF and has a defined path forward to final disposal.

B.2.2 Waste Management Decision Process

All aqueous waste under consideration for acceptance must be characterized using analytical data and/or knowledge. This information is used to determine the acceptability of an aqueous waste stream. The LERF and 200 Area ETF Facility Manager or their designee is responsible for making the decision to accept or reject an aqueous waste stream. The management decision to accept any aqueous waste stream is based on an evaluation of regulatory acceptability and operational acceptability. Each evaluation uses acceptance criteria, which were developed to ensure that an aqueous waste is managed in a safe, environmentally sound, and in compliance with this Permit. The following sections provide detail on the acceptance evaluation and the acceptance criteria.

An aqueous waste stream could be rejected for one of the following reasons:

- The paperwork and/or laboratory analyses from the generator are insufficient
- Discrepancies with the regulatory and operational acceptance criteria cannot be reconciled, including:
  - An aqueous waste, which is not allowed under the current ~~Washington State Waste Discharge Permit (No. ST 4500) or~~ Final Delisting 200 Area ETF, and LERF and 200 Area ETF management elect not to pursue an amendment, or the ~~Permit and~~ Final Delisting 200 Area ETF cannot be amended (Section B.2.2.1)
  - An aqueous waste is incompatible with LERF liner materials or with other aqueous waste in LERF and no other management method is available (Section B.2.2.3.1 ~~B.2.2.2.2~~).

Adequate storage or treatment capacity is not available.

B.2.2.1 Regulatory Acceptability

Each aqueous waste stream is evaluated on a case-by-case basis to determine if there are any regulatory concerns that would preclude the storage or treatment of a waste in the LERF or 200 Area ETF based on the criteria in Sections B.2.2.1.1 ~~and B.2.2.1.2~~. Before an aqueous waste can be stored or treated in either the LERF or 200 Area ETF, the waste designation must be determined. Information on the waste designation of an aqueous waste is documented in the waste profile sheet. This information is used to confirm that treating or storing the aqueous waste in the LERF or 200 Area ETF is allowed under and in compliance with WAC 173-303, Permit (WA7890008967), ~~200 Area ETF Delisting~~ Final Delisting 200 Area ETF in 40 CFR 261, Appendix IX, Table 2 incorporated by reference by WAC 173-303-910(3), and the corresponding State-Issued Delisting~~, and the Washington State Waste Discharge Permit (No. ST 4500)~~ for 200 Area ETF.

B.2.2.1.1 Dangerous Waste Regulations, State and Federal Delisting Actions, and Permits

Before an aqueous waste stream is sent to the LERF or 200 Area ETF, the generator will characterize and designate the stream with the appropriate dangerous/hazardous waste numbers according to WAC 173-303-070. Addendum A, the ~~200 Area ETF Delisting~~ Final Delisting 200 Area ETF and the corresponding State-Issued Delisting identify the specific waste numbers for dangerous/mixed waste that can be managed in the LERF and 200 Area ETF. Dangerous waste designated with waste numbers not specified in these documents cannot be treated or stored in the LERF or 200 Area ETF, unless the documents are appropriately modified.

Additionally, aqueous wastes designated with listed waste numbers identified in the ~~200 Area ETF Delisting~~ Final Delisting 200 Area ETF and the corresponding State-Issued Delisting will be managed in accordance with the conditions of the delisting, or an amended delisting.

~~B.2.2.1.2 State Waste Permit Regulations/Permit~~

~~Compliance with the Washington State Waste Discharge Permit (No. ST 4500), constitutes another waste acceptance criterion. In accordance with the permit conditions of the Washington State Waste Discharge Permit (No. ST 4500), the constituents of concern in each new aqueous waste stream must be identified. The waste designation and characterization data provided by the generator are used to identify these constituents. The Washington State Waste Discharge Permit (No. ST 4500), defines a constituent of concern in an aqueous waste stream, under the conditions of the Discharge Permit, as any contaminant with a maximum concentration greater than one of the following:~~

~~Any limit in the Washington State Waste Discharge Permit (No. ST 4500)~~
~~Groundwater Quality Criteria (WAC 173-200)~~
~~Final Delisting level (40 CFR 261, Appendix IX, Table 2)~~

~~The corresponding State-Issued Delisting Background groundwater concentration as measured at the SALDS disposal site. The practical quantification limit (PQL) is used for the groundwater background concentration for constituents not analyzed or not detected in the SALDs background data.~~

~~The Permit conditions of the Washington State Waste Discharge Permit (No. ST 4500), also require a demonstration that 200 Area ETF can treat the constituents of concern to below discharge limits.~~

B.2.2.2 Operational Acceptability

Because the operating configuration or operating parameters at the LERF and 200 Area ETF can be adjusted or modified, most aqueous waste streams generated on the Hanford Site can be effectively treated to below Delisting and Discharge Permit limits. Because of this flexibility, it would be impractical to define numerical acceptance or decision limits. Such limits would constrain the acceptance of appropriate aqueous waste streams for treatment at the LERF and 200 Area ETF. The versatility of the LERF and 200 Area ETF is better explained in the following examples:

- The typical operating configuration of 200 Area ETF is to process an aqueous waste through the UV/OX unit first, followed by the RO unit. However, high concentrations of nitrates may interfere with the performance of the UV/OX. In this case, 200 Area ETF could be configured to process the waste in the RO unit prior to the UV/OX unit.
- For a small volume aqueous waste with high concentrations of some anions and metals, the approach may be to first process the waste stream in the secondary treatment train. This approach would prevent premature fouling or scaling of the RO unit. The liquid portion (i.e., untreated overheads from 200 Area ETF evaporator and thin film dryer) would be sent to the primary treatment train.
- An aqueous waste with high concentrations of chlorides and fluorides may cause corrosion problems when concentrated in the secondary treatment train. One approach is to adjust the corrosion control measures in the secondary treatment train. An alternative may be to blend this aqueous waste in a LERF basin with another aqueous waste, which has sufficient dissolved solids, such that the concentration of the chlorides in the secondary treatment train would not pose a corrosion concern.
- Some metal salts (e.g., barium sulfate) tend to scale the RO membranes. In this situation, descalants used in the treatment process may be increased.
- Any effluent that does not meet these limits in one pass through 200 Area ETF treatment process is recycled to 200 Area ETF for re-processing.

There are some aqueous wastes, whose chemical and physical properties preclude that waste from being treated or stored at the LERF or 200 Area ETF. Accordingly, an aqueous waste is evaluated to determine if it is treatable, if it would impair the efficiency or integrity of the LERF or 200 Area ETF, and if it is compatible with materials in these units. This evaluation also determines if the aqueous waste is compatible with other aqueous wastes managed in the LERF.

The waste acceptance criteria in this category focus on determining treatability of an aqueous waste stream, and on determining any operational concerns that would prohibit the storage or treatment of an aqueous waste stream in the LERF or 200 Area ETF. The chemical and physical properties of an aqueous waste stream are determined as part of the waste characterization, and are documented on the waste profile sheet and compared to the design of the units to determine whether an aqueous waste stream is appropriate for storage and treatment in the LERF and 200 Area ETF. All decisions and supporting rationale and data will be documented in the Hanford Facility Operating Record, LERF and 200 Area ETF File according to Permit Condition II.I.

B.2.2.3 Special Requirements Pertaining to Land Disposal Restrictions

Containers of 200 Area ETF secondary waste are transferred to a storage or final disposal unit, as appropriate (e.g., the Central Waste Complex or to the Environmental Restoration Disposal Facility). 200 Area ETF personnel provide the analytical characterization data and necessary process knowledge for the waste to be managed by the receiving staff, and the appropriate LDR documentation.

The following information on the secondary waste is included on the LDR documentation provided to the receiving unit:

- Dangerous waste numbers (as applicable)
- Determination on whether the waste is restricted from land disposal according to the requirements of 40 CFR 268 incorporated by reference by WAC 173-303-140 (i.e., the LDR status of the waste)

The waste tracking information associated with the transfer of waste

- Waste analysis results.

Generally, the operating parameters or operating configuration at the LERF or 200 Area ETF can be adjusted or modified to accommodate these properties. However, in those cases where a treatment process or operating configuration cannot be modified, the aqueous waste stream will be excluded from treatment or storage at the LERF or 200 Area ETF. Additionally, an aqueous waste stream is evaluated for the potential to deposit solids in a LERF basin (i.e., whether an aqueous waste contains sludge or could precipitate solids). This evaluation will also consider whether the blending or mixing of two or more aqueous waste streams will result in the formation of a precipitate. However, because the waste streams managed in the LERF and 200 Area ETF are generally dilute, the potential for mixing waste streams and forming a precipitate is low; no specific compatibility tests are performed. Filtration at the waste source could be required before acceptance into LERF. Waste streams with the potential to form precipitates in LERF or that cannot be blended with other waste streams to avoid precipitate formation are not accepted for treatment at LERF and 200 Area ETF. The 2025-ED Load-~~i~~In Station~~Facility~~ has the ability to perform filtration on incoming waste streams going to both the LERF and ~~200 Area ETF~~ 2025-ED Load-~~i~~In Station. See additional discussions of precipitate formation and compliance with LDR requirements in Section B.3. Similar filtration requirements could apply to aqueous waste fed directly to 200 Area ETF without interim treatment in LERF.

To determine if an aqueous waste meets the criterion of treatability, specific information is required. Treatability of a waste stream is evaluated from characterization data provided by the generator as verified through the waste acceptance process, the 200 Area waste acceptance criteria, and the treatability envelope for the 200 Area ETF as documented in Tables C.1 and C.2 of the November 29, 2001 delisting petition. Generators will also provide characterization data to identify those physical and chemical properties that would interfere with, or foul 200 Area ETF treatment process in consultation with LERF and 200 Area ETF representatives. In some instances, knowledge that meets the definition of *knowledge* in WAC 173-303-040 is used for purposes of identifying a chemical or physical property that would be of concern. For example, the generator could provide knowledge that the stream has two phases (an oily phase and an aqueous phase). In this case, if the generator could not physically separate the two phases, the aqueous waste stream would be rejected because the oily phase could compromise some of the treatment equipment. Typically, analyses for the following parameters are required to evaluate treatability and operational concerns:

- total dissolved solids
- total organic carbon
- total suspended solids
- barium
- calcium
- chloride
- nitrite
- phosphate
- potassium

- specific conductivity
- pH
- alkalinity
- ammonia
- fluoride
- iron
- magnesium
- nitrate
- silicon
- sodium
- sulfate

These constituents are identified in Table B.2, which is the list of target analytes used for waste characterization and waste acceptance evaluation.

B.2.2.3.1 Compatibility

Corrosion Control. Because of the materials of construction used in 200 Area ETF, corrosion is generally not a concern with new aqueous waste streams. Additionally, these waste streams are managed in a manner that minimizes corrosion. To ensure that a waste will not compromise the integrity of 200 Area ETF tanks and process equipment, each waste stream is assessed for its corrosion potential as part of the compatibility evaluation. This assessment usually focuses on chloride and fluoride concentrations; however, the chemistry of each new waste also is evaluated for other parameters that could cause corrosion.

Compatibility with Liquid Effluent Retention Facility Liner and Piping. As part of the acceptance process, the criteria of compatibility with the LERF liner materials are evaluated for each aqueous waste stream. This evaluation is performed using knowledge (as defined by WAC 173-303-040) of constituent concentrations in the aqueous waste stream or using constituent concentrations obtained by analyzing the waste stream for the constituents identified in Table B.1 using the analytical methods for these constituents in Section B.8~~B.9~~. Then, the constituent concentrations in the waste stream are compared to the decision criteria in Table B.1. If all constituent concentrations are below the decision criteria, then the waste stream is considered compatible with the LERF liner and may be accepted for treatment. Otherwise, the waste stream is considered incompatible with the LERF liner, and it cannot be accepted for treatment in the LERF basins. However, a waste stream may still be acceptable for treatment in 200 Area ETF if it is fed directly to 200 Area ETF, bypassing the LERF Basins. Results of this evaluation are documented in the Hanford Facility Operating Record, LERF and 200 Area ETF File according to Permit Condition II.I. The rational for establishing the liner compatibility constituents and decision criteria in Table B.1 is as follows: The high-density polyethylene liners in the LERF basins potentially are vulnerable to the presence of certain constituents that might be present in some aqueous waste. Using EPA SW-846, Method 9090, the liner materials were tested to evaluate compatibility between aqueous waste stored in the LERF and synthetic liner components. Based on the data from the compatibility test and vendor data on the liner materials, several constituents and parameters were identified as potentially harmful (at high concentrations) to the integrity of the liners. From these data and the application of safety factors, concentration limits in Table B.1 were established.

The strategy for protecting the integrity of a LERF liner is to establish upfront that an aqueous waste is compatible before the waste is accepted into LERF. Characterization data on each new aqueous waste stream are compared to the limits outlined in Table B.1 to ensure compatibility with the LERF liner material before acceptance into the LERF.

Before a waste stream is processed at the 242-A Evaporator, the generator reviews DST analytical data and a process condensate profile is developed to ensure the process condensate is compatible with the LERF liner. For flow through aqueous wastes like the 200-UP-1 Groundwater, characterization data will be obtained and reviewed every two years to ensure that liner compatibility is maintained.

In some instances, knowledge may be adequate to determine that an aqueous waste is compatible with the LERF liner. When knowledge is used, it must satisfy the definition of *knowledge* in WAC 173-303-040. In those instances where knowledge is adequate, the waste characterization would likely not require

analysis for these parameters and constituents. Storm water is an example where knowledge is adequate to determine that this aqueous waste is compatible with the LERF liner.

Compatibility with Other Waste. Some aqueous wastes, especially small volume streams, are accumulated in the LERF with other aqueous waste. Before acceptance into the LERF, the aqueous waste stream is evaluated for its compatibility with the resident aqueous waste(s). The evaluation focuses on the potential for an aqueous waste to react with another waste (40 CFR 264, Appendix V, *Examples of Potentially Incompatible Wastes*) including formation of any precipitate in the LERF basins. However, the potential for problems associated with commingling aqueous wastes is very low due to the dilute nature of the wastes; this evaluation confirms the compatibility of two or more aqueous wastes from different sources. Compatibility is determined by evaluating parameters such as pH, ammonia, and chloride. No specific analytical test for compatibility is performed.

If it is determined that an aqueous waste stream is incompatible with other aqueous waste streams, alternate management scenarios are available. For example, another LERF basin that contains a compatible aqueous waste(s) might be used, or the aqueous waste stream might be fed directly into 200 Area ETF for treatment. In any case, potentially incompatible waste streams are not mixed, and all aqueous waste is managed in a way that precludes a reaction, degradation of the liner, or interference with 200 Area ETF treatment process.

B.2.3 Periodic Review Process

In accordance with WAC 173-303-300(4)(a), an influent aqueous waste will be periodically reviewed as necessary to ensure that the characterization is accurate and current. At a minimum, an aqueous waste stream will be reviewed in the following situations.

- The LERF and 200 Area ETF management have been notified, or have reason to believe that the process generating the waste has changed.
- The LERF and 200 Area ETF management note an increase or decrease in the concentration of a constituent in an aqueous waste stream, beyond the range of concentrations that was described or predicted in the waste characterization.
- Waste streams will be reviewed every two years.

In these situations, LERF and 200 Area ETF management will review the available information. If existing analytical information is not sufficient, the generator may be asked to review and update the current waste characterization, to supply a new WPS, or re-sample and re-analyze the aqueous waste, as necessary. Other situations that might require a re-evaluation of a waste stream are discussed in the following sections.

B.2.4 Record/Information and Decision

The information and data collected throughout the acceptance process, and the evaluation and decision on whether to accept an influent aqueous waste stream for treatment or storage in the LERF or 200 Area ETF are documented as part of Hanford Facility Operating Record, LERF and 200 Area ETF File pursuant to Permit Condition II.I. Specifically, the Hanford Facility Operating Record, LERF and 200 Area ETF File contains the following components on a new influent aqueous waste stream:

- The signed WPS for each aqueous waste stream and analytical data
- Knowledge used to characterize a dangerous/mixed waste (under WAC 173-303), and information supporting the adequacy of the knowledge
- The evaluation on whether an aqueous waste stream meets the waste acceptance criteria, including:
    - The evaluation for regulatory acceptability including appropriate regulatory approvals
    - The evaluation for LERF liner compatibility and for compatibility with other aqueous waste

Table B.1. General Limits for Liner Compatibility

Chemical Family	Constituent(s) or Parameter(s)[1]	Limit ~~(mg/L)~~[2] (sum of constituent concentrations)
Alcohol/glycol	1-butanol	500,000 mg/L 500,000 ppm
Alkanone[3]	acetone,	200,000 mg/L 200,000 ppm
Alkenone[4]	none targeted	N/A
Aromatic/cyclic hydrocarbon	acetophenone, benzene, carbozole, chrysene, cresol, di-n-octyl phthalate, diphenylamine, isophorone, pyridine, tetrahydrofuran	2,000 mg/L 2,000 ppm
Halogenated hydrocarbon	arochlors, carbon tetrachloride, chloroform, hexachlorobenzene, lindane (gamma-BHC), hexachlorocyclopentadiene, methylene chloride, p-chloroaniline, tetrachloroethylene, 2,4,6-trichlorophenol	2,000 mg/L 2,000 ppm
Aliphatic hydrocarbon	none targeted	N/A
Ether	dichloroisopropyl ether	2,000 mg/L 2,000 ppm
Other hydrocarbons	acetontrile, carbon disulfide, n-nitrosodimethylamine, tributyl phosphate	2,000 mg/L 2,000 ppm
Oxidizers	none targeted	NA
Acids, Bases, Salts	ammonia, cyanide, anions, cations	100,000 mg/L 100,000 ppm
pH	pH	0.5 < pH < 13.0

[1] Analytical methods for the parameters and constituents are provided in Section B.8.
[2] Analytical data are evaluated using the following 'sum of the fraction' technique. The individual constituent concentration is evaluated against the compatibility limit for its chemical family. The sum of the evaluations must be less than 1. pH is not part of this evaluation.

$$\sum_{n=1}^{i}\left(\frac{\text{Conc}_n}{\text{LIMIT}_n}\right) \le 1$$

[3] Ketone containing saturated alkyl group(s)
[4] Ketone containing unsaturated alkyl group(s)
Where 'i' is the number of organic constituents detected
mg/L = milligrams per liter
ppm = parts per million
NA = not applicable

~~[1] Analytical methods for the parameters and constituents are provided in Section B.9~~
~~[2] Analytical data are evaluated using the following 'sum of the fraction' technique. The individual constituent concentration is evaluated against the compatibility limit for its chemical family. The sum of the evaluations must be less than 1. pH is not part of this evaluation.~~

$$\sum_{n=1}^{i}\left(\frac{\text{Conc}_n}{\text{LIMIT}_n}\right) \le 1$$

~~[3] Ketone containing saturated alkyl group(s)~~
~~[4] Ketone containing unsaturated alkyl group(s)~~
~~Where 'i' is the number of organic constituents detected~~
~~mg/L = milligrams per liter~~
~~NA = not applicable~~

Table B.2. Waste Acceptance Criteria

General Criteria Category	Criteria description
1. Characterization	A. Each generator must provide an aqueous waste profile.
	B. Each generator must designate the aqueous waste stream.
	C. Each generator must provide analytical data and/or knowledge.
2. Regulatory acceptability	A. The LERF and 200 Area ETF can store and treat influent aqueous wastes with waste numbers identified in Addendum A for the LERF and 200 Area ETF, and the Final Delisting 200 Area ETF~~200 Area ETF Delisting~~, 40 CFR 261, Appendix IX, Table 2 incorporated by reference by WAC 173-303-910(3).
	B. The aqueous waste must comply with conditions of the Discharge Permit.
3. Operational acceptability	A. Determine whether an aqueous waste stream is treatable, considering: 1. Whether the removal and destruction efficiencies on the constituents of concern will be adequate to meet the Discharge Permit and Delisting levels 2. Other treatability concerns; analyses for this evaluation may include: total dissolved solids, total organic carbon, total suspended solids, specific conductivity, alkalinity, ammonia, barium, calcium, chloride, fluoride, iron, magnesium, nitrate, nitrite, phosphate, potassium, silicon, sodium, sulfate, pH
	B. Determine whether an aqueous waste stream is compatible, considering: 1. Whether an aqueous waste stream presents corrosion concerns with respect to 200 Area ETF; analysis may include chloride and fluoride 2. Whether an aqueous waste stream is compatible with LERF liner materials, compare characterization data to the liner compatibility limits (Table B.1). 3. Whether an aqueous waste stream is compatible with other aqueous waste(s), 40 CFR 264, Appendix V, comparison will be used.

B.3 Special Management Requirements

Special management requirements for aqueous wastes that are managed in the LERF or 200 Area ETF are discussed in the following section.

B.3.1 Land Disposal Restriction Compliance at Liquid Effluent Retention Facility

Because LERF provides treatment through flow and pH equalization, a surface impoundment treatment exemption from the land disposal restrictions was granted in accordance with 40 CFR 268.4, and WAC 173-303-040. This treatment exemption is subject to several conditions, including a requirement that the WAP address the sampling and analysis of the treatment 'residue' [40 CFR 268.4(a)(2)(i) and WAC 173-303-300(5)(h)(i) and (ii)] to ensure the 'residue' meets applicable treatment standards. Though

the term 'residue' is not specifically defined, this condition further requires that sampling must be designed to represent the "sludge and the supernatant" indicating that a residue may have a sludge (solid) and supernatant (liquid) component.

Solid residue is not anticipated to accumulate in a LERF basin for the following reasons:

- Aqueous waste streams containing sludge would not be accepted into LERF under the acceptance criteria of treatability (Section B.2.2.3.1~~B.2.2.2.1~~)
- No solid residue was reported from process condensate discharged to LERF in 1995
- The LERF basins are covered and all incoming air first passes through a breather filter
- No precipitating or flocculating chemicals are used in flow and pH equalization.
- Multiple waste streams managed in a single LERF basin are evaluated for the formation of precipitates. Wastes that would form precipitates are not accepted for treatment at LERF.

Therefore, the residue component subject to this condition is the supernatant (liquid component). Additionally, an aqueous waste stream is evaluated for the potential to deposit solids in a LERF basin (i.e., an aqueous waste that contains suspended solids). If necessary, filtration at the waste source could be required before acceptance into LERF. Therefore, the residue component in LERF subject to this condition is the supernatant (liquid component). The contingency for removal of solids will be addressed during closure in Addendum H, Closure Plan.

The conditions of the treatment exemption also require that treatment residues (i.e., aqueous wastes), which do not meet the LDR treatment standards "must be removed at least annually" [40 CFR 268.4(a)(2)(ii) incorporated by reference by WAC 173-303-140]. To address the conditions of this exemption, an influent aqueous waste is sampled and analyzed and the LDR status of the aqueous waste is established as part of the acceptance process. The LERF basins are then managed such that any aqueous waste(s), which exceeds an LDR standard, is removed annually from a LERF basin, except for a heel of approximately 1 meter (3 feet). A heel is required to stabilize the LERF liner. The volume of the heel is approximately ~~1.9 million~~ 2,082,000 liters (550,006 gallons).

B.4 Influent Aqueous Waste Sampling and Analysis

The following sections provide a summary of the sampling procedures, frequencies, and analytical parameters for characterization of influent aqueous waste (Section B.2) and in support of the special management requirements for aqueous waste in the LERF (Section B.3).

B.4.1 Sampling Procedures

With a few exceptions, generators are responsible for the characterization, including sampling and analysis, of an influent aqueous waste. Process condensate is either sampled at the 242-A Evaporator or accumulated in a LERF basin following a 242-A Evaporator campaign and sampled. Other exceptions will be handled on a case-by-case basis and the Hanford Facility Operating Record, LERF and 200 Area ETF File will be maintained at the unit for inspection by Ecology. The following section discusses the sampling locations, methodologies, and frequencies for these aqueous wastes. For samples collected at the LERF and 200 Area ETF, unit-specific sampling protocol is followed. The sample containers, preservation materials, and holding times for each analysis are listed in Section B.8~~B.9~~.

B.4.1.1 Batch Samples

In those cases where an aqueous waste is sampled in a LERF basin, samples are collected from four of the six available sample risers located in each basin, i.e., four separate samples. When LERF levels are low, fewer than four samples can be taken if the sampling approach is still representative. Though there are eight sample risers at each basin, one is dedicated to liquid level instrumentation and another is dedicated as an influent port. Operating experience indicates that four samples adequately capture the spatial variability of an aqueous waste stream in the LERF basin. Specifically, sections of stainless steel (or other compatible material) tubing are inserted into the sample riser to an appropriate depth. Using a portable pump, the sample line is flushed with the aqueous waste and the sample collected. The grab

sample containers typically are filled for volatile organic compounds (VOC) analysis first, followed by the remainder of the containers for the other parameters.

Several sample ports are also located at 200 Area ETF, including a valve on the recirculation line at 200 Area ETF surge tank, and a sample valve on a tank discharge pump line at ~~200 Area ETF~~the 2025-ED Load-~~i~~In Station. All samples are obtained at the LERF or 200 Area ETF are collected in a manner consistent with SW-846 procedures (EPA as amended).

B.4.2 Analytical Rationale

As stated previously, each generator is responsible for designating and characterizing an aqueous waste stream. Accordingly, each generator samples and analyzes an influent waste stream using the target list of parameters (Table B.3) for the waste acceptance process. At the discretion of the LERF and 200 Area ETF management, a generator may provide knowledge in lieu of some analyses as discussed in Section B.2.1.1. The LERF and 200 Area ETF personnel will work with the generator to determine which parameters are appropriate for the characterization.

The analytical methods for these parameters are provided in Section B.8~~B.9~~. All methods are EPA methods satisfying the requirements of WAC 173-303-110(3). Additional analyses may be required if historical information and knowledge indicate that an influent aqueous waste contains constituents not included in the target list of parameters. For example, if knowledge indicates that an aqueous waste contains a parameter that is regulated by the Groundwater Quality Criteria (WAC 173-200), that parameter(s) would be added to the suite of analyses required for that aqueous waste stream.

The analytical data for the parameters presented in Table B.3, including VOC, SVOC, metals, anions, and general chemistry parameters are used to define the physical and chemical properties of the aqueous waste for the following:

- Set operating conditions in the LERF and 200 Area ETF (e.g., to determine operating configuration , refer to Section B.2.2.2)
- Identify concentrations of some constituents which may also interfere with, or foul 200 Area ETF treatment process (e.g., fouling of the RO membranes, refer to Section B.2.2.2)
- Evaluate LERF liner and piping material compatibility
- Determine treatability to evaluate if applicable constituents in the treated effluent will meet Discharge Permit and Delisting limits
- Estimate concentrations of some constituents in the waste generated in the secondary treatment train (i.e., dry powder waste).

Table B.3. Target Parameters for Influent Aqueous Waste Analyses

VOLATILE ORGANIC COMPOUNDS	SEMIVOLATILE ORGANIC COMPOUNDS
Acetone	Acetophenone
Acetonitrile	Cresol (o, p, m)
Benzene	Dichloroisopropyl ether (bis(2-chloropropyl)ether)
1-Butanol	Di-n-octyl phthalate
Carbon disulfide	Diphenylamine
Carbon tetrachloride	Hexachlorobenzene
Chloroform	Hexachlorocyclopentadiene
Methylenechloride	Isophorone
Tetrachloroethylene	Lindane (gamma-BHC)
Tetrahydrofuran	N-nitrosodimethylamine
	Pyridine
	Tributyl phosphate
	2,4,6-Trichlorophenol

TOTAL METALS		ANIONS
Arsenic	Magnesium	Chloride
Barium	Mercury	Fluoride
Beryllium	Nickel	Nitrate
Cadmium	Potassium	Nitrite
Calcium	Selenium	Phosphate
Chromium	Silicon	Sulfate
Copper	Silver	**GENERAL CHEMISTRY PARAMETERS**
Iron	Sodium	Ammonia
Lead	Vanadium	Cyanide
	Zinc	pH
		Total suspended solids
		Total dissolved solids
		Total organic carbon
		Specific conductivity

B.5 Treated Effluent Sampling and Analysis

The treated aqueous waste, or effluent, from 200 Area ETF is collected in three ~~2,940,000~~3,025,739-liter (799,316-gallons) verification tanks before discharge to the SALDS. To determine whether the ~~D~~discharge ~~Permit early warning values, enforcement~~ limits, and the Final Delisting 200 Area ETF criteria are met, the effluent routinely is sampled at the verification tanks. The sampling and analyses performed are described in the following sections.

B.5.1 Rationale for Effluent Analysis Parameter Selection

The parameters measured in the treated effluent are required by the following regulatory documents:

Delisting criteria from the Final Delisting 200 Area ETF (40 CFR 261, Appendix IX, Table 2 incorporated by reference by WAC 173-303-910(3))

Corresponding State Final Delisting issued pursuant to WAC 173-303-910(3)

~~•~~ Effluent limits from the Discharge Permit Number ST0004500~~Washington State Waste Discharge Permit (No. ST 4500)~~

~~• Early warning values from the Washington State Waste Discharge Permit (No. ST 4500)~~

The Final Delisting 200 Area ETF provides two testing regimes for the treated effluent. Initial verification testing is performed when a new influent waste stream is processed through the 200 Area ETF. For each 200 Area ETF influent waste stream, the first generated verification tank must be sampled and analyzed for all delisting constituents and conductivity. Subsequent verification sampling and analysis of all delisting parameters is performed on every 15th tank of that 200 Area ETF influent waste stream. If the concentration of any analyte is found to exceed a Discharge Permit

Number ST0004500~~Washington State Waste Discharge Permit (No. ST 4500)~~, enforcement limit or a Delisting criterion, the contents of the verification tank are reprocessed and/or re-analyzed. The next verification tank generated is also sampled for all delisting constituents. ~~If the concentration of any analyte exceeds an early warning value, an early warning value report is prepared and submitted to Ecology.~~

B.5.2 Effluent Sampling Strategy: Methods, Location, Analyses, and Frequency

Effluent sampling methods and locations, the analyses performed, and frequency of sampling are discussed in the following sections.

B.5.2.1 Effluent Sampling Method and Location

Samples of treated effluent are collected and analyzed to verify the treatment process using 200 Area ETF specific sampling protocol. These verification samples are collected at a sampling port on the verification tank recirculation line. Section B.8~~B.9~~ presents the sample containers, preservatives, and holding times for each parameter monitored in the effluent.

B.5.2.2 Analyses of Effluent

The parameters required by the current Discharge Permit Number ST0004500~~Washington State Waste Discharge Permit (No. ST 4500)~~, and Final Delisting 200 Area ETF, conditions are presented in Table B.4. The analytical methods and PQLs associated with each parameter are provided in Section B.8~~B.9~~. The methods and PQLs are equivalent to those used in the analysis of influent aqueous waste.

B.5.2.3 Frequency of Sampling

Treated effluent is tested for all parameters listed in Table B.4 on a frequency satisfying the permit conditions of the Discharge Permit Number ST0004500~~Washington State Waste Discharge Permit (No. ST 4500)~~, and the Final Delisting 200 Area ETF. This effluent must meet the Discharge Permit Number ST0004500~~Washington State Waste Discharge Permit (No. ST 4500)~~, and Final Delisting 200 Area ETF limits associated with these parameters. Grab samples are collected from each verification tank.

During operation of 200 Area ETF, if one or more of the constituents exceeds a Delisting criterion, the Delisting conditions require:

The characterization data and processing strategy of the influent waste stream be reviewed and changed accordingly to ensure the contents of subsequent tanks do not exceed the Delisting criteria

The contents of the verification tank are recycled for additional treatment. The contents that are recycled are resampled after treatment to ensure no constituents exceed a Delisting criteria

The contents of the following verification tank are sampled for compliance with the Delisting criteria.

Treated effluent that does not meet Discharge Permit Number ST0004500~~Washington State Waste Discharge Permit (No. ST 4500)~~ is not discharged to the SALDS until the tank has been retreated and/or reanalyzed.

B.6 Effluent Treatment Facility Generated Waste Sampling and Analysis

The wastes discussed in this section include the wastes generated at 200 Area ETF and are managed in the container storage areas of 200 Area ETF. This section describes the characterization of the following secondary waste streams generated within 200 Area ETF:

Secondary waste generated from the treatment process, including the following waste forms:

- dry powder waste
- concentrate tanks slurry

- sludge removed from process tanks

Waste generated by operations and maintenance activities

Miscellaneous waste generated within 200 Area ETF.

For each waste stream described, a characterization methodology and rationale are provided, and sampling requirements are addressed.

B.6.1 Secondary Waste Generated from Treatment Processes

The following terms used in this Section, including powder, dry powder, waste powder, and dry waste powder, are equivalent to the term 'dry powder waste'.

A dry powder waste is generated from the secondary treatment train, from the treatment of an aqueous waste. Waste is received in the secondary treatment train in waste receiving tanks where it is fed into an evaporator. Concentrate waste from the evaporator is then fed to a concentrate tank. From these tanks, the waste is fed to a thin film dryer and dried into a powder, and collected into containers. The containers are filled via a remotely controlled system. The condensed overheads from the evaporator and thin film dryer are returned to the surge tank to be fed to the primary treatment train.

Occasionally, salts from the treatment process (e.g., calcium sulfate and magnesium hydroxide) accumulate in process tanks as sludge. Because processing these salts could cause fouling in the thin film dryer, and to allow uninterrupted operation of the treatment process, the sludge is removed and placed in containers. The sludge is dewatered and the supernate is pumped back to 200 Area ETF for treatment.

The secondary treatment system typically receives and processes the following by-products generated from the primary treatment train:

- Concentrate from the first RO stage
- Backwash from the rough and fine filters
- Regeneration waste from the ion exchange system
- Spillage or overflow collected in the process sumps.

In an alternate operating scenario, some aqueous wastes may be fed to the secondary treatment train before the primary treatment train.

B.6.1.1 Special Requirements Pertaining to Land Disposal Restrictions

Containers of 200 Area ETF secondary waste are transferred to a storage or final disposal unit, as appropriate (e.g., the Central Waste Complex or to the Environmental Restoration Disposal Facility). 200 Area ETF personnel provide the analytical characterization data and necessary knowledge for the waste to be managed by the receiving staff, and for the appropriate LDR documentation.

The following information on the secondary waste is included on the LDR documentation provided to the receiving unit:

Dangerous waste numbers (as applicable)

Determination on whether the waste is restricted from land disposal according to the requirements of 40 CFR 268 incorporated by reference by WAC 173-303-140 (i.e., the LDR status of the waste)

The waste tracking information associated with the transfer of waste

- Waste analysis results.

B.6.1.2 Sampling Methods

The dry powder waste and containerized sludge are sampled from containers using the principles presented in SW-846 (EPA as amended) and ASTM Methods (American Society for Testing Materials),

as referenced in WAC 173-303-110(2). The sample container requirements, sample preservation requirements, and maximum holding times for each of the parameters analyzed in either matrix are presented in Section B.8~~B.9~~.

Concentrate tank waste samples are collected from recirculation lines, which provide mixing in the tank during pH adjustment and prevent caking. The protocol for concentrate tank sampling prescribes opening a sample port in the recirculation line to collect samples directly into sample containers. The sample port line is flushed before collecting a grab sample. The VOC sampling typically is performed first for grab samples. Each VOC sample container will be filled such that cavitation at the sample valve is minimized and the container has no headspace. The remainder of the containers for the other parameters will be filled next.

Table B.4. Rationale for Parameters to be Monitored in Treated Effluent

Parameter	(Cas No.)	Final Delisting 200 Area ETF[1]	ST0004500 Discharge Permit[2]	
			~~Enforcement~~ Effluent Limit	~~Early Warning Value~~
VOLATILE ORGANIC COMPOUNDS				
Acetone	(67-64-1)	X	X	
Acetonitrile	(75-05-8)	X		
Benzene	(71-43-2)	X	X	~~X~~
1-Butanol	(71-36-3)	X		
Carbon disulfide	(75-15-0)	X		
Carbon tetrachloride	(56-23-5)	X	X	
Chloroform	(67-66-3)		X	~~X~~
Methylene Chloride	(75-09-2)		M	
Tetrachloroethylene	(127-18-4)		X	
Tetrahydrofuran	(109-99-9)	X	X	~~X~~
SEMIVOLATILE ORGANIC COMPOUNDS				
Acetophenone	(98-86-2)		X	
Carbazole	(86-74-8)	X		
p-Chloroaniline	(106-47-8)	X		
Chrysene	(218-01-9)	X		
Cresol (total)	(1319-77-3)	X		
Dichloroisopropyl ether (bis(2-chloroisopropyl)ether)	(108-60-1)	X		
Di-n-octyl phthalate	(117-84-0)	X		
Diphenylamine	(122-39-4)	X		
Hexachlorobenzene	(118-74-1)	X		
Hexachlorocyclopentadiene	(77-47-4)	X		
Isophorone	(78-59-1)	X		
Lindane (gamma-BHC)	(58-89-9)	X		
N-nitrosodimethylamine	(62-75-9)	X	X	
Pyridine	(110-86-1)	X		
Tributyl phosphate	(126-73-8)	X		
2,4,6-Trichlorophenol	(88-06-2)	X		
PCBs				
Aroclor 1016	(12674-11-2)	X		
Aroclor 1221	(11104-28-2)	X		
Aroclor 1232	(11141-16-5)	X		
Aroclor 1242	(53469-21-9)	X		
Aroclor 1248	(12672-29-6)	X		
Aroclor 1254	(11097-69-1)	X		
Aroclor 1260	(11096-82-5)	X		

Table B.4. Rationale for Parameters to be Monitored in Treated Effluent				
		Final Delisting 200 Area ETF[1]	ST0004500 Discharge Permit[2]	
Parameter	(Cas No.)		~~Enforcement~~ Effluent Limit	~~Early Warning Value~~
TOTAL METALS[3]				
Arsenic	(7440-38-2)	X	X	
Barium	(7440-39-3)	X		
Beryllium	(7740-41-7)	X	X	
Cadmium	(7440-43-9)	X	X	~~X~~
Chromium	(7440-47-3)	X	X	
Copper	(7440-50-8)		X	~~X~~
Lead	(7439-92-1)	X	X	~~X~~
Mercury	(7439-97-6)	X	X	~~X~~
Nickel	(7440-02-0)	X		
Selenium	(7782-49-2)	X		
Silver	(7440-22-4)	X		
Vanadium	(7440-62-2)	X		
Zinc	(7440-66-6)	X		
ANIONS				
Chloride	(16887-00-6)		X	
Fluoride	(16984-48-8)	X		
Nitrate (as N)	(14797-55-8)		X	
Nitrite (as N)	(1479765-0)		X	
Sulfate	(14808-79-8)		X	
OTHER ANALYSES				
Ammonia	(7664-41-7)	X	X	
Cyanide	(57-12-5)	X		
Total dissolved solids			X	~~X~~
Total organic carbon			X	
Total suspended solids			X	
Specific conductivity			M	

[1]Parameters required by the current conditions of the Final Delisting 200 Area ETF, 40 CFR 261, Appendix IX, Table 2 incorporated by reference by WAC 173-303-910(3),70 FR 44496 (EPA 2005)
[2]Parameters required by the current conditions of the Discharge Permit Number ST0004500~~State Waste Discharge Permit, No. ST 4500~~
[3]Metals reported as total concentrations
X = Rationale for measuring this parameter in treated effluent
M = Monitor only; no limit defined
PCBs = polychlorinated biphenyls

B.6.1.3 Sampling Frequency

When designation or identification of applicable LDR treatment standards of the 200 Area ETF secondary waste cannot be based on influent characterization data or knowledge as described in Section B.6.1.1, 200 Area ETF secondary waste is sampled on a batch basis. A batch is defined as any volume of aqueous waste that is being treated under consistent and constant process conditions.

When personnel exposures are of concern, one representative sample will be collected from the concentrate tank, if waste from the concentrate tank. The sample will be analyzed for the appropriate parameters identified in Table B.5 based on the needs identified from evaluating influent waste analysis data. If sampling of the concentrate tank is not technically practicable for purposes of designating the powder, direct sampling of the dry powder will be used to make determinations on the dry powder. The dry powder or concentrate tanks will be resampled in the following situations:

- Change in influent characterization

- Change in process chemistry, as indicated by in-line monitoring of conductivity and pH
- The LERF and 200 Area ETF management have been notified, or have reason to believe that the process generating the waste has changed (for example, a source change such as a change in the well-head for groundwater that significantly changes the aqueous waste characterization).
- The LERF and 200 Area ETF management note an increase or decrease in the concentration of a constituent in an aqueous waste stream, beyond the range of concentrations that was described or predicted in the waste characterization.

B.6.2 Operations and Maintenance Waste Generated at the 200 Area Effluent Treatment Facility

Operation and maintenance of process and ancillary equipment generates additional routine waste. These waste materials are segregated to ensure proper handling and disposition, and to minimize the commingling of potentially dangerous waste with nondangerous waste. The following waste streams are anticipated to be generated during routine operation and maintenance of 200 Area ETF. This waste might or might not be dangerous waste, depending on the nature of the material and its exposure to a dangerous waste.

- Spent lubricating oils and paint waste from pumps, the dryer rotor, compressors, blowers, and general maintenance activities
- Spent filter media and process filters
- Spent ion exchange resin
- HEPA filters
- UV light tubes
- RO membranes
- Equipment that cannot be returned to service
- Other miscellaneous waste that might contact a dangerous waste (e.g., plastic sheeting, glass, rags, paper, waste solvent, or aerosol cans).

These waste streams are stored at 200 Area ETF before being transferred for final treatment, storage, or disposal as appropriate. This waste is characterized and designated using knowledge (from previously determined influent aqueous waste composition information); analytical data; and material safety data sheets (MSDS) of the chemical products present in the waste or used (the data sheets are maintained at 200 Area ETF). Sampling of these waste streams is not anticipated; however, if an unidentified or unlabeled waste is discovered, that waste is sampled. This 'unknown' waste is sampled and analyzed for the parameters in Table B.5 as appropriate, and will be designated according to Washington state regulatory requirements. The specific analytical methods for these analyses are provided in Section B.8~~B.9~~.

B.6.3 Other Waste Generated at the 200 Area Effluent Treatment Facility

There are two other potential sources of waste at 200 Area ETF: spills and/or overflows, and discarded chemical products. Spills may be subject to the requirements of Permit Condition II.E. Spilled material that potentially might be dangerous waste generally is either containerized or routed to 200 Area ETF sumps where the material is transferred either to the surge tank for treatment or to the secondary treatment train. In most cases, knowledge and the use of MSDSs are sufficient to designate the waste material. If the source of the spilled material is unknown and the material cannot be routed to 200 Area ETF sumps, a sample of the waste is collected and analyzed according to Table B.5, as necessary, for appropriate characterization of the waste. Unknown wastes will be designated according to Washington State regulatory requirements at WAC 173-303-070. The specific analytical methods for these analyses are provided in Section B.8~~B.9~~.

A discarded chemical product waste stream could be generated if process chemicals, cleaning agents, or maintenance products become contaminated or are otherwise rendered unusable. In all cases, these materials are appropriately containerized and designated. Sampling is performed, as appropriate, for waste designation.

Table B.5. 200 Area Effluent Treatment Facility Generated Waste - Sampling and Analysis

Parameter[1]	Rationale
• Total solids or percent water[2]	• Calculate dry weight concentrations
• Volatile organic compounds[3]	• LDR - verify treatment standards
• Semi-volatile organic compounds[3]	• LDR - verify treatment standards
• Metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver)	• Waste designation • LDR - verify treatment standards
• Cation and anions of concern	• Address receiving TSD unit waste acceptance requirements
• pH	• Waste designation

1 For influent and concentrate tank samples, the total sample (solid plus liquid) is analyzed and the analytical result is expressed on a dry weight basis. The result for toxicity characteristic metal and organic is divided by a factor of 20 and compared to the toxicity characteristic (TC) constituent limits [WAC 173-303-090(8)]. If the TC limit is met or exceeded, the waste is designated accordingly. All measured parameters are compared against the corresponding treatment standards.

2 Total solids or percent water are not determined for unknown waste and dry powder waste samples and are analyzed in maintenance waste and sludge samples, as appropriate (i.e., percent water might not be required for such routine maintenance waste as aerosol cans, fluorescent tubes, waste oils, batteries, etc., or sludge that has dried).

3 VOC and/or SVOC analysis of secondary waste is required unless influent characterization data and knowledge indicate that the constituent will not be in the final secondary waste at or above the LDR.

LDR = land disposal restrictions
TSD = treatment, storage, and/or disposal

B.7 Quality Assurance/Quality Control

The following quality assurance/quality control (QA/QC) plan for LERF and 200 Area ETF is provided as required by WAC 173-303-810(6) and follows the guidelines of EPA QA/G-5.

B.7.1 Project Management

The following sections address project administrative functions and approaches.

B.7.1.1.1 Project Organization

Overall management of the LERF and 200 Area ETF is performed by the Facility Manager, who is responsible for safe operation of the facility, including implementation of this QA/QC plan and compliance with applicable permits and regulations. The Facility Manager also provides retention of project records in accordance with this plan. Assisting the Facility Manager is an Environmental Field Representative that monitors compliance, reviews new requirements and regulations, and interfaces with EPA and Ecology. Also assisting the Facility Manager is a QA representative who is responsible for implementing the QA program at the facility.

Reporting to the Facility Manager are several support groups. The Operations group consists of trained personnel who operate the plant, including operators performing sampling activities such as collection, packaging, and transportation of samples to the laboratory. The Maintenance group is responsible for performing calibrations and preventative maintenance on facility equipment, including pH, conductivity, and flow meters required by environmental permits. The Engineering group monitors the process with online instruments and sampling for process control. The Engineering group also performs waste

acceptance, and environmental compliance activities, including scheduling sampling, generating data forms, and reviewing data.

B.7.1.2 Special Training

Individuals involved in sampling, analysis, and data review will be trained and qualified to implement safely the activities addressed in this WAP and QA/QC plan. Training will conform to the training requirements specified in WAC 173-303-330 and ~~the LERF/200 Area ETF Dangerous Waste Training Plan (~~Addendum F, Personnel Training~~)~~. Training records will be maintained in accordance with Section B.7.1.3 ~~of this WAP~~.

B.7.1.3 Documentation and Records

Sample records are documented as part of the Hanford Facility Operating Record, LERF and 200 Area ETF File pursuant to Permit Condition II.I. These documents and records include the following:

- Training
- Chains of Custody for all regulatory sampling performed by LERF and 200 Area ETF
- Data Summary Reports
- QA/QC reports
- Assessment reports
- Instrument inspection, maintenance, and calibration logs

B.7.2 Data Quality Parameters and Criteria

Data quality parameters are listed by EPA QA/G-5S, *Guidance for Choosing a Sampling Design for Environmental Data Collection* as:

- Purpose of Data Collection (e.g. determining if a parameter exceeds a threshold level)
- Spatial and Temporal Boundaries of Study
- Preliminary Estimation of Sample Support (volume that each sample represents)
- Statistical Parameter of Interest (e.g. mean, percentile, percentage), and
- Limits on Decision Error/Precision (e.g. false acceptance error, false rejection error)

The parameters for the first four bullets (limits, sample points, frequency of samples, etc.) are already established in the permits, delisting petition, and this WAP. The focus of this QA/QC plan is on limits on decision error/precision.

The data quality parameters were chosen to ensure Limits on Decision Error/Precision are appropriate for purposes of using the data to demonstrate compliance with permits, delisting exclusion limits, and this WAP. The principal quality parameters are precision, accuracy, representativeness, comparability, and completeness. Secondary data parameters of importance include sensitivity and detection levels. The data quality parameters and the data acceptance criteria are discussed below.

B.7.2.1 Precision

Precision is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions. Precision is expressed in terms of the relative percent difference (RPD) for duplicate measurements. QA/QC sample types that test precision include field and laboratory duplicates and spike duplicates. The RPDs for laboratory duplicates and/or matrix spike duplicates will be routinely calculated.

$$\text{RPD} = (100)\textit{absolute value of}\left(\frac{\text{sample result} - \text{duplicate sample result}}{\text{average of sample result} + \text{duplicate sample result}}\right)$$

Matrix spike duplicates are replicates of matrix spike samples that are analyzed with every analytical batch that contains ~~an~~ 200 Area ETF treated effluent sample. The precision of the analytical methods are estimated from the results of the matrix spike (MS) and the matrix spike duplicate (MSD) for selected analytes. Matrix spike analyses cannot be performed for certain analytical methods, including conductivity, pH, and total dissolved solids. Duplicate analyses are used to determine the RPD for these methods. The precision acceptance criteria are specified in Table B.6.

B.7.2.2 Accuracy

Accuracy assesses the closeness of the measured value to an accepted reference value. Accuracy of analytical results is typically assessed using matrix spikes. A matrix spike is the addition of a known amount of the analyte to the sample matrix being analyzed. Accuracy is expressed as a percent recovery of the spiked samples.

$$\text{Percent Recovery} = 100\left(\frac{\text{matrix spike sample result} - \text{sample result}}{\text{spiked amount}}\right)$$

Matrix spike analyses cannot be performed on certain analytical methods, including conductivity, pH, and total dissolved solids. The percent recovery for the laboratory control standard samples demonstrates that these methods are working properly and gives an estimate of the method's accuracy. The percent recovery will be routinely calculated.

Accuracy criteria are established to provide confidence that the result is below the action level. Therefore the closer the result is to the action level the higher the degree of accuracy needed. The upper and lower accuracy acceptance criteria are specified in Table B.6. The criteria are reasonable values based on previous analysis of constituents in the delisting exclusion, or similar constituents.

B.7.2.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent selected characteristics of a parameter at a sampling point or process condition. Because of the matrix being analyzed, dilute aqueous solution, it is not expected that representativeness will be of concern, except when there are potential for changes to process conditions such as the facility influent concentrations or waste processing strategy. Sampling due to these changes in process conditions is addressed in Section B.6.1.3 ~~of this WAP~~.

The representativeness of a sample may be compromised by the presence of contaminants introduced in the field or the laboratory. To determine if contamination may be present, a blank sample of reagent water is analyzed. A method blank is performed by the laboratory on every batch of 20 samples being analyzed at the same time. The presence of a constituent in the sample and the blank sample indicates contamination has occurred.

B.7.2.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system, expressed as a percentage of the number of valid measurements that were planned to be collected. Lack of completeness is sometimes caused by loss of a sample, loss of data, or inability to collect the planned number of samples. Incompleteness also occurs when data are discarded because they are of unknown or unacceptable quality. Since most regulatory sampling events performed by LERF and ~~/~~200 Area ETF involve a single sample, all analysis must be complete and valid.

B.7.2.5 Comparability

Comparability is the confidence with which one data set can be compared to another. Comparability is achieved by using sampling and analytical techniques, which provide for measurements that are consistent and representative of the media and conditions measured. In laboratory analysis, the term comparability focuses on method type, holding times, stability issues, and aspects of overall analytical quantitation.

B.7.2.6 Sensitivity and Detection Levels

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. Sensitivity represents the maximum value for a detection level that will reasonably assure the results are below the established limits. The analytical method selected by LERF and/~~-~~200 Area ETF should have a detection level for each constituent that is below the sensitivity. The preferred detection level is the practical quantitation limit (PQL), which is lowest concentration that can be reliably measured during routine laboratory conditions. If the method PQL cannot meet the sensitivity for some constituents, the minimum concentration or attribute that can be measured by a method (method detection limit) or by an instrument (instrument detection limit) may be used. The sensitivity levels, specified in Table B.6, are derived from the delisting limits, water discharge limits, and uncertainty values, which are based on the required precision and accuracy for each constituent.

B.7.3 Data Generation and Acquisition

The following section addresses QA requirements for data generation and acquisition.

B.7.3.1 Sampling Method

LERF and/~~-~~200 Area ETF samples required by the permits and delisting are collected as grab samples. Sampling for the purpose of waste designation of secondary waste is performed using grab, composite, thief, scoop, or composite liquid waste sampler (COLIWASA). The selection of the sample collection device depends on the type of sample, the sample container, the sampling location, and the nature and distribution of the waste components. In general, the methodologies used for specific materials correspond to those referenced to WAC 173-303-110(2). The selection and use of the sampling device is supervised or performed by a person thoroughly familiar with the sampling requirements.

The following protocol applies to all sampling methods:

- All containers will be filled within as short a time period as reasonably achievable.
- Volatile Organic Analysis (VOA) sample containers will be filled first, and prior to any subdividing of a composited sample.
- VOA samples consisting of a set of two or more sample containers will be filled sequentially. The sample containers are considered equivalent and given identical sampling times.
- All VOA sample containers must have no headspace and be free of trapped air bubbles.
- Grab sample protocol includes:
  - Sample lines should be as short as reasonably achievable and free of traps and pockets in which solids might settle.
  - The sample line should be flushed before sampling with a minimum volume equivalent to three times the sample line volume.
  - Contamination to the sample from contact with the internal and external surfaces of the tap should be minimized.

Thief and COLIWASA samplers are used to sample liquid waste containers such as drums. Scoop samplers are used to sample powder waste generated in the thin-film dryer. Sample requirements for these samples include:

- Thief or COLIWASA sampler, the sampler should be lowered into the liquid slowly so the level of the liquid inside and outside the sampler tube remain about the same.
- When lifting the thief or COLIWASA sampler from the solution, the outside should be wiped down, or the excess water allowed to drip off, before filling the sample container.

B.7.3.2 Sample Handling, Custody, and Shipping

The proper handling of sample bottles after sampling is important to ensure the samples are free of contamination and to demonstrate the samples have not been tampered with.

B.7.3.2.1 Chain-of-Custody

Evidence of collection, shipment, receipt at the laboratory, and laboratory custody until disposal will be documented using a chain-of-custody form. The chain-of-custody form will, as a minimum identify sample identification number, sampling date and time, sampling location, sample bottle type and number, analyses to be performed, and preservation method.

The operations person who signs as the collector on the chain of custody is the first custodian of the samples. A custodian must maintain continuous custody of sample containers at all times from the time the sample is taken until delivery to the laboratory or until delivery to a common carrier for shipment to an off-site location. Custody is maintained by any of the following:

- The custodian has the samples in view, or has placed the samples in locked storage, or keeps the samples within a secured area (e.g., controlled by authorized personnel only), or has applied a tamper-indicating device, such as evidence tape, to the sample containers or shipping containers.
- The custodian has taken physical possession of the samples or the shipping containers sealed with an intact tamper-indicating device, such as evidence tape.

B.7.3.2.2 Sample Preservation, Containers, and Holding Time

Table B.6 lists the sample container, preservation method, and holding time requirements for different types of analyses. These parameters are based on the requirements of 40 CFR 136, Table II.

B.7.3.3 Instrument Calibration and Preventive Maintenance

LERF and ~~/~~ 200 Area ETF uses instruments to monitor operations and meet regulatory requirements. This includes continuous pH and conductivity monitors required by facility permits and delisting. All instruments are calibrated according to frequencies and tolerances established by the LERF and ~~/~~200 Area ETF engineering group. Calibrations and other maintenance actions are scheduled and tracked by LERF and~~/~~ 200- Area ETF maintenance group using a preventive maintenance database. Measuring and test equipment used for instrument calibration is controlled, calibrated at specified intervals, and maintained to establish accuracy limits.

B.7.4 Assessment and Oversight

Quality programs can only be effective if meaningful assessments are performed to monitor and respond to issues associated with program performance. Routine assessment of data is performed as part of the validation process discussed in Section B.7.5.1.

B.7.4.1 Assessments and Response

Management assessments are conducted by first line management and subject matter experts, focusing on procedural adequacy, compliance, and overall effectiveness of the program. Management assessments of the sample program typically include the LERF and 200 Area ETF QA representative. Each management assessment has a performance objective or lines of inquiry. Examples may include personnel training, proper performance of sample custody, or completeness of sampling records.

B.7.4.2 Reports to Management

Results of performance assessments, including any issues identified, are provided to the LERF and 200 Area ETF Facility Manager in a written report. The Facility Manager is responsible to correct all findings from the report.

B.7.5 Verification and Validation of Analytical Data

The data verification and validation processes will ensure that the data resulting from the selected analytical method are consistent with requirements specified in this QA/QC plan.

B.7.5.1 Data Verification

The primary data reporting will be by electronic data systems. Data verification will be performed on laboratory data packages that support environmental compliance to ensure that their content is complete and in order. A review of the data package will be performed to ensure that:

- The data package contains the required technical information
- Deficiencies are identified and documented
- Identified deficiencies are corrected by the laboratory and the appropriate revisions are made
- Deficient pages are replaced with the laboratory corrections
- A copy of the completed verification report is placed in the data file

B.7.5.2 Data Validation

Data validation ensures that the data resulting from analytical measurements meet the quality requirements specified in the QA/QC plan. Data validation will be performed on data packages that support environmental compliance.

The following are included in data validation:

- Chain-of-Custody – Verify the COC shows unbroken custody from sampling through receipt at the laboratory.
- Request analysis – Review the sample results to verify the requested analysis was performed. If an alternate method was used, verify permit-required detection limits were met.
- Holding times – Review the sample results to verify the analyses were performed within required holing times and where applicable, extraction times.
- Blank – Review the results of trip, field, and equipment blank samples to verify the sample results are not compromised by contamination.
- Laboratory QC – Verify the laboratory QC was completed and there are no outstanding problems

~~B.8 REFERENCES~~

~~DOE/RL-92-72, *200 Area Effluent Treatment Facility Delisting Petition,* Revision 1, 1993, U.S. Department of Energy, Richland Operations Office, Richland, Washington.~~

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~~EPA, 1983, *Methods for Chemical Analysis of Water Wastes*, EPA-600/4-79/020, (as amended), National Exposure Research Laboratory, Cincinnati, Ohio~~

~~EPA, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846* (Third Edition, as amended), U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.~~

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~~U.S. Environmental Protection Agency, Region 10 to J. Hennig, U.S. Department of Energy, December 6, 1994.~~

~~EPA, 2005, 200 Area ETF Delisting [Exclusion], issued to U.S. Department of Energy, 40 CFR 261, Appendix IX, Table 2 (, August 3, 2005), U.S. Environmental Protection Agency, Washington, D.C.~~

B.8 ~~B.9.~~ Analytical Methods, Sample Containers, Preservative Methods, and Holding Times

Table B.6. Sample and Analysis Criteria for Influent Aqueous Waste and Treated Effluent				
Parameter	**Analytical Method[1]**	**Method PQL Sensitivity[2]**	**Accuracy/ Precision for Method[3] (percent)**	**Sample container[4]/ Preservative[4]/ Holding time[5]**
VOLATILE ORGANIC COMPOUNDS				
Acetone	SW-846 8260 or EPA-600 624	40	60-120 / 20	Sample container 3 x 40-mL amber glass with septum Preservative HCl to pH<2; 4°C Holding time 14 days
Acetonitrile		820	60-120 / 20	
Benzene		5	60-120 / 20	
1-Butanol		1600	60-120 / 20	
Carbon Disulfide		1500	60-120 / 20	
Carbon tetrachloride		5	60-120 / 20	
Chloroform		5	50-130 / 20	
Methylene chloride		5	50-150 / 20	
Tetrachloroethylene		5	65-140 / 20	
Tetrahydrofuran		100	60-120 / 20	
SEMIVOLATILE ORGANIC COMPOUNDS				
Acetophenone	SW-846 8270 or EPA-600 625	10	70-110 / 25	Sample container 4 x 1-liter amber glass Preservative 4°C Holding time 7 days for extraction; 40 days for analysis after extraction
Carbazole		110	50-120 / 25	
p-Chloroaniline		76	50-120 / 25	
Chrysene		350	50-120 / 25	
Cresol (o, p, m)		760	50-120 / 25	
Di-n-octyl phthalate		300	50-120 / 25	
Diphenylamine		350	50-120 / 25	
Hexachlorobenzene		2	50-120 / 25	
Hexachlorocyclopentadiene		110	50-120 / 25	
Isophorone		2600	50-120 / 25	
Lindane (gamma-BHC)		1.9	50-120 / 25	
N-nitrosodimethylamine		12	50-120 / 25	
Pyridine		15	50-120 / 25	
Tributyl phosphate		76	50-120 / 25	
2.4.6-Trichlorophenol		230	50-120 / 25	

Table B.6. Sample and Analysis Criteria for Influent Aqueous Waste and Treated Effluent				
Parameter	**Analytical Method[1]**	**Method PQL Sensitivity[2]**	**Accuracy/ Precision for Method[3] (percent)**	**Sample container[4]/ Preservative[4]/ Holding time[5]**
POLYCHLORINATED BIPHENYLs (PCBs)				
Aroclor-1016	SW-846 8082	0.4	50-110 / 25	Sample container 4 x 1-liter amber glass Preservative 4°C Holding time 1 year for extraction; 1 year for analysis after extraction
Aroclor-1221		0.4	50-110 / 25	
Aroclor-1232		0.4	50-110 / 25	
Aroclor-1242		0.4	50-110 / 25	
Aroclor-1248		0.4	50-110 / 25	
Aroclor-1254		0.4	50-110 / 25	
Aroclor-1260		0.4	50-110 / 25	
TOTAL METALS				
Arsenic	EPA-600 200.8	11	70-130 / 20	Sample container 1 x 0.5-liter plastic/glass Preservative 1:1 HNO_3 to pH<2 Holding time 180 days; mercury 28 days
Beryllium		34	75 - 125 / 20	
Cadmium		5	70-130 / 20	
Chromium		20	70-130 / 20	
Copper		70	70-130 / 20	
Lead		10	70-130 / 20	
~~Mercury~~		~~2~~	~~70-130 / 20~~	
Selenium		20	70-130 / 20	
Barium	SW-846 6010/ EPA-600 200.7	1200	75 - 125 / 20	
~~Beryllium~~		~~34~~	~~75 - 125 / 20~~	
Calcium		200	75 - 125 / 20	
Iron		100	75 - 125 / 20	
Magnesium		400	75 - 125 / 20	
Nickel		340	75 - 125 / 20	
Potassium		10,000	75 - 125 / 20	
Silicon		580	75 - 125 / 20	
Silver		83	75 - 125 / 20	
Sodium		2500	75 - 125 / 20	
Vanadium		120	75 - 125 / 20	
Zinc		5100	75 - 125 / 20	
Mercury	SW-846 7470, or EPA-600 245.1	2	70-130 / 20	

Table B.6. Sample and Analysis Criteria for Influent Aqueous Waste and Treated Effluent				
Parameter	**Analytical Method[1]**	**Method PQL Sensitivity[2]**	**Accuracy/ Precision for Method[3] (percent)**	**Sample container[4]/ Preservative[4]/ Holding time[5]**
GENERAL CHEMISTRY				
Chloride	EPA-600 300.0	1000	70-130 / 20	Sample container 1 x 60-mL plastic/glass Preservative 4°C Holding time 28 days; nitrate and nitrite 48 hours
Fluoride		880	70-130 / 20	
Formate		1250	70-130	
Nitrate (as N)		100	70-130 / 20	
Nitrite (as N)		100	70-130 / 20	
Phosphate		1500	70-130 / 20	
Sulfate		10,000	70-130 / 20	
Ammonia (as N)	EPA-600, 300.7, or EPA-600 350.1	40	70-130 / 20	Sample container 1 x 50-mL glass or plastic Preservative H_2SO_4 to pH<2; 4°C Holding time 28 days
Cyanide	EPA-600 335.2/335.3	350	70-130 / 20	Sample container 1 x 250-mL glass or plastic Preservative NaOH to pH>12; 4°C Holding time 14 days
Alkalinity	EPA-600 310.1/310.2	ND	ND	Sample container 1 x 50-mL glass or plastic Preservative 4°C Holding time 14 days
Total dissolved solids	EPA-600 160.1 or SM2540C	ND	ND	Sample container 1 x 500-mL glass or plastic Preservative 4°C Holding time 7 days
Total suspended solids	EPA-600 160.2 or SM2540D	ND	ND	Sample container 1 x 1-L glass or plastic Preservative 4°C Holding time 7 days

Table B.6. Sample and Analysis Criteria for Influent Aqueous Waste and Treated Effluent

Parameter	Analytical Method[1]	Method PQL Sensitivity[2]	Accuracy/ Precision for Method[3] (percent)	Sample container[4]/ Preservative[4]/ Holding time[5]
Specific conductivity	EPA-600 120.1 (in lab) or SM2510B	ND	ND	Sample container 1 x 50-mL glass or plastic Preservative 4°C Holding time 28 days
pH[7]	EPA-600 150.1 or SM4500-H⁺B	ND	ND	Sample container 1 x 60-mL glass or plastic Preservative None Holding time Analyze immediately
Total organic carbon	SW-846 9060 or SMC5310	ND	ND	Sample container 1 x 250-mL amber glass Preservative H_2SO_4 to pH<2; 4°C Holding time 28 days

[1]SW-846 or EPA-600 methods are presented unless otherwise noted. Other methods might be substituted if the applicable PQL can be met.
[2]~~ST-4500~~ST00045000 required method PQL or Delisting Exclusion condition 2 report sensitivity/detection level, whichever is lower. Units are parts per billion unless otherwise noted.
[3]Accuracy/precision used to confirm or re-establish MDL
[4]Sample bottle, volumes, and preservatives could be adjusted, as applicable, for safety reasons
[5]Holding time = time between sampling and analysis
[7]pH monitored in influent aqueous waste only

0°C = Celsius = 32°Fahrenheit
L = liter = 0.26 gallons
mL = milliliter = 0.03 ounces
NA = not applicable
ND = not determined
MDL = method detection level
PQL = practical quantitation limit
RL = reporting limit

Table B.7. Sample Containers, Preservative Methods, and Holding Times for 200 Area ETF Generated Waste

Parameter	Analytical Method[1]	Method PQL	Accuracy/ Precision for Method (percent)	Sample container[2,4]/ Preservative[2,4]/ Holding time[3,2]
Liquid Matrix				
For methods other than total solids, analyze using the methods and QA/QC in Table B.6. For each method, analyze the target compound list				
Total solids	EPA-600 160.3	ND	ND	Sample container 1 x 500-mL glass or plastic Preservative – 4°C Holding time –7 days
Solid Matrix				
Volatile organic compounds (combined method target compound lists)	SW-846 8260	Refer to Table B.6	Refer to Table B.6	Sample container 1 x 40-mL amber glass with septum Preservative –4°C Holding time –14 days
Semi-volatile organic compounds (method target compound list)	SW-846 8270	Refer to Table B.6	Refer to Table B.6	Sample container 1 x 125-mL amber glass Preservative –4°C Holding time –14 days for extraction; 40 days for analysis after extraction
PCBs (method target compound list)	SW-846 8082	Refer to Table B.6	Refer to Table B.6	Sample container Amber glass – 50 g of sample Preservative –4°C Holding time –1 year for extraction; 1 year for analysis after extraction
RCRA Metals (method target compound list)	EPA-600 200.8	Refer to Table B.6	Refer to Table B.6	Sample container glass or plastic – 10 g of sample Preservative –none, mercury 4°C Holding time –180 days; mercury 28 days
Total Metals (method target compound list)	SW-846 6010	Refer to Table B.6	Refer to Table B.6	
Anions (method target compound list)	EPA-600 300.0	Refer to Table B.6	Refer to Table B.6	Sample container glass or plastic –25 g of sample Preservative –none Holding time –6 months for extraction; 28 days for analysis after extraction, nitrate and nitrite 48 hours for analysis after extraction
Ammonia	EPA-600 300.7	Refer to Table B.6	Refer to Table B.6	Sample container glass or plastic – 25 g of sample Preservative –none Holding time –6 months for extraction; 28 days for analysis after extraction
pH	SW-846 9045	ND	ND	Sample container glass or plastic – 50 g of sample Preservative –none Holding time –none
Toxicity Characteristic Leaching Procedure[4,3]	SW-846 1311	NA	NA	Sample container Refer to specific method being performed after TCLP – 125 g of sample Preservative –None (after TCLP, preserve extract per method being performed) Holding time –Metals: 180 days for TCLP extraction, mercury 28 days for TCLP extraction

Table B.7. Sample Containers, Preservative Methods, and Holding Times for 200 Area ETF Generated Waste

Parameter	Analytical Method[1]	Method PQL	Accuracy/ Precision for Method (percent)	Sample container[2]/ Preservative[2]/ Holding time[3]
				SVOA: 14 days for TCLP extraction (after TCLP, refer to specific methods for time for analysis after extraction)

[1]SW 846 or EPA-600 methods are presented unless otherwise noted. Other methods might be substituted if the applicable PQL can be met.

[2] Sample bottle, volumes, and preservatives could be adjusted, as applicable, for safety reasons

[3] Holding time equals time between sampling and analysis

[4] Extraction procedure, as applicable; extract analyzed by referenced methods [WAC 173-303-110(3)(c)]

°C = Celsius = 32°Fahrenheit
g = grams = 0.0352 ounces
mL = milliliter = 0.03 ounces
NA = not applicable
PQL = practical quantitation limit
~~mL = milliliter~~
ND = not determined
TCLP = toxicity characteristic leaching procedure

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ADDENDUM C
PROCESS INFORMATION

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ADDENDUM C
PROCESS INFORMATION

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C. PROCESS INFORMATION

This addendum provides a detailed discussion of the LERF and 200 Area ETF processes and equipment. The LERF and 200 Area ETF comprise an aqueous waste treatment system located in the 200 East Area that provides storage and treatment for a variety of aqueous mixed waste. This aqueous waste includes process condensate from the 242-A Evaporator and other aqueous waste generated from onsite remediation and waste management activities.

The LERF consists of three lined surface impoundments, or basins. Aqueous waste from LERF is pumped to the 200 Area ETF for treatment in a series of process units, or systems, that remove or destroy essentially all of the dangerous waste constituents. The treated effluent is discharged to a State-Approved Land Disposal Site (SALDS) north of the 200 West Area, under the authority of a Washington State Waste Discharge Permit ~~(Ecology 2000)~~ST0004500 and the ~~Final Delisting~~Final Delisting 200 Area ETF (40 CFR 261, Appendix IX, Table 2).

Both LERF and 200 Area ETF waste processing operations are controlled in a central Control ~~r~~Room located in the ~~200 Area ETF~~ 2025-E building. The 200 Area ETF Control Room~~control room~~ is staffed continuously during 200 Area ETF processing operations. Processing operations are defined as when liquid transfers of any sort are occurring to/from/within the LERF and 200 Area ETF or when wastes are being treated at 200 Area ETF[1]. Examples of processing operations include, but are not limited to, when liquid waste are transferred to/from the LERF basins [see Section C.1], during active liquid waste treatment/processing at the 200 Area ETF (e.g., liquid waste treatment in tanks and liquid waste movement between primary and secondary treatment train processes and/or other 200 Area ETF tanks [see Section C.2]~~)~~, and liquid waste receipts at the ~~l~~Load-~~i~~In ~~s~~Station [see Section C.2.1]). Section C.2.5.1 describes the centralized computer system (i.e., monitor and control system or MCS) that is located at the 200 Area ETF ~~c~~Control ~~r~~Room and other locations at the 200 Area ETF ~~facility~~. The~~is~~ MCS monitors the performance of the 200 Area ETF operations and records alarms from various equipment as described in this Addendum C and Addendum I, Inspection Requirements. At times when processing operations are not occurring, the 200 Area ETF Control ~~r~~Room is not manned continuously, and alarms are monitored daily as specified in Addendum I.

C.1 Liquid Effluent Retention Facility Process Description

Each of the three LERF basins has an operating capacity of 29.5-million liters (7.8 million gallons). The LERF receives aqueous waste through several inlets including the following:

- A pipeline that connects LERF with the 242-A Evaporator
- A pipeline from the 200 West Area
- A pipeline that connects LERF to the Load-In Station (2025-ED) ~~at the 200 Area ETF~~
- A series of sample ports located at each basin.

Figure C.1 presents a general layout of LERF and associated pipelines. Aqueous waste from LERF is pumped to the 200 Area ETF through one of two double-walled fiberglass transfer pipelines. Effluent from the 200 Area ETF also can be transferred back to the LERF through one of these transfer pipelines. These pipelines are equipped with leak detection located in the annulus between the inner and outer pipes. In the event that these leak detectors are not in service, the pipelines are visually inspected during transfers for leakage by opening the secondary containment drain lines located at the 200 Area ETF end of the transfer pipelines.

Each basin is equipped with six available sample risers constructed of 15.2-centimeter (6-inch) perforated pipe. A seventh sample riser in each basin is dedicated to influent aqueous waste receipt piping (except for aqueous waste received from the 242-A Evaporator), and an eighth riser in each basin contains liquid level instrumentation. Each riser extends along the sides of each basin from the top to the bottom of the basin and allows samples to be collected from any depth. Personnel access to these sample ports is from the perimeter area of the basins.

-Liquid transfers does not include standard facility operations of liquid recirculation (e.g. for pump seals), sanitary water and cooling water, and outdoor rainwater management activities.

A catch basin is provided at the northwest corner of each LERF basin for aboveground piping and manifolds for transfer pumps. Aqueous waste from the 242-A Evaporator is transferred through piping which ties into piping at the catch basins. Under routine operations, a submersible pump is used to transfer aqueous waste from a LERF basin to the 200 Area ETF for processing or for basin-to-basin transfers. This pump is connected to a fixed manifold on one of four available risers.

Each basin consists of a multilayer liner system supported by a concrete anchor wall around the basin perimeter and a soil-bentonite clay underlayment. The multilayer liner system consists of a primary liner in contact with the aqueous waste, a layer of bentonite carpet, a geonet, a geotextile, a gravel layer, and a secondary liner that rests on the bentonite underlayment. Any aqueous waste leakage through the primary liner flows through the geonet and gravel to a leachate collection system. The leachate flows to a sump at the northwest corner of each basin, where the leachate is pumped up the side slope and back into the basin above the primary liner. Each liner is constructed of high-density polyethylene. A floating cover made of very low-density polyethylene is stretched over each basin above the primary liner. These covers serve to keep unwanted material from entering the basins, and to minimize evaporation of the liquid contents.

C.2 200 Area Effluent Treatment Facility Process Description

The 200 Area ETF is designed as a flexible treatment system that provides treatment for contaminants anticipated in process condensate and other onsite aqueous waste. The design influent flow rate into the 200 Area ETF is approximately 570 liters (150 gallons) per minute, with planned outages for activities such as maintenance on the 200 Area ETF systems. Maintenance outages typically are scheduled between treating a batch of aqueous waste, referred to as treatment campaigns. The effluent flow (or volume) is equivalent to the influent flow (or volume).

The 200 Area ETF generally receives aqueous waste directly from the LERF. However, aqueous waste also can be transferred from tanker trucks at the Load-In Station (2025-ED) ~~to the 200 Area ETF~~ and from containers (e.g., carboys, drums) directly to building 2025-E~~ETF~~. Aqueous waste is treated and stored in ~~the 200 Area ETF~~ 2025-E ~~p~~Process ~~a~~Area in a series of tank systems, referred to as process units. Within ~~the~~ building 2025-E~~ETF~~, waste also is managed in containers through treatment and/or storage. Figures C.2 and C.3 provides the relative locations of the process and container storage areas within the 200 Area ETF.

The process units are grouped in either the primary or the secondary treatment train. The primary treatment train provides for the removal or destruction of contaminants. Typically, the secondary treatment train processes the waste by-products from the primary treatment train by reducing the volume of waste. In the secondary treatment train, contaminants are concentrated and dried to a powder. The liquid fraction is routed to the primary treatment train. Figure C.2~~C.3~~ provides an overview of the layout of the ~~ETF,~~ 2025-E ~~B~~building and the Load-In Station). Figure C.34 presents the ~~200 Area ETF~~ Building 2025-E Ground ~~f~~Floor ~~p~~Plan, which includes the relative locations of the individual process units and associated tanks ~~within the ETF~~, and the location of the Load-In Station.

The dry powder waste and maintenance and operations waste are containerized and stored or treated in the container storage areas or in collection or treatment areas within the 2025-E Process Area. Secondary containment is ~~provided for all~~discussed in Section C.3.4, for containers and in Section C.4.3 for tank systems (including ancillary equipment) housed within ~~the ETF~~ building 2025-E. The trenches and floor of building 2025-E~~the 200 Area ETF~~ comprise the secondary containment system. The floor includes approximately a 15.2-centimeter (6-inch) rise (berm) along the containing walls of the 2025-E ~~p~~Process Area and 2025-E ~~e~~Container ~~s~~Storage ~~a~~Areas. Any spilled or leaked material from within the 2025-E ~~p~~Process ~~a~~Area or 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area is collected into trenches that feed into either ~~s~~Sump ~~t~~Tank 1 or ~~s~~Sump ~~t~~Tank 2.

From these sump tanks, the spilled or leaked material (i.e., waste) is fed to either the surge tank and processed in the primary treatment train or the secondary waste receiving tanks and processed in the secondary treatment train. All tank systems outside of ~~the 200 Area ETF~~ building 2025-E are provided with a secondary containment system.

In the following sections, several figures are provided that present general illustrations of the treatment units and the relation to the process.

C.2.1 Load-In Station

The 200 Area ETF receives aqueous waste from LERF or the Load-In Station (2025-ED). The ~~200 Area ETF~~ Load-In Station, located due east of the surge tank and outside of the perimeter fence (Figure C.2~~C.4~~), was designed and constructed to provide the capability to unload, store, and transfer aqueous waste to the LERF or 200 Area ETF from tanker trucks and other containers (such as drums). The Load-In Station consists of two truck bays equipped with ~~l~~Load-~~i~~In Station tanks, transfer pumps, filtration system, level instrumentation for tanker trucks, leak detection capabilities for the containment basin and transfer line, and an underground transfer line that connects to lines in the surge tank berm, allowing transfers to either the ~~200 Area ETF~~ surge tank or LERF. The Load-In Station is covered with a steel building for weather protection. Tanker trucks and other containers are used to unload aqueous waste at the Load-In Station. To perform unloading, the tanker truck is positioned on a truck pad, a 'load-in' transfer line is connected to the truck, and the tanker contents are pumped into one of the Load-In Station tanks, the surge tank, or directly to the LERF. For container unloading, the container is placed on the truck pad and the container contents are pumped into one of the Load-In Station tanks, the surge tank, or directly to the LERF.

During unloading operations, solids may be removed from the waste by pumping the contents of the tanker truck or container through a filtration system. If solids removal is not needed, the filtration system is not used and the solution is transferred directly to the Load-In Station tanks, surge tank, or to LERF.

Any leaks at the Load-In Station drain to the sump. A leak detector in the sump alarms locally and in the 200 Area ETF ~~e~~Control ~~r~~Room. Alarms are monitored continuously in the 200 Area ETF ~~e~~Control ~~r~~Room during Load-~~i~~In Station transfers and at least daily at times when waste is not being received at the Load-In Station. Alternatively, leaks can be visually detected.

C.2.2 200 Area Effluent Treatment Facility Operating Configuration

Because the operating configuration of the 200 Area ETF can be adjusted or modified, most aqueous waste streams can be effectively treated to below permitting ~~Delisting and Discharge Permit~~ limits. The operating configuration of the 200 Area ETF depends on the unique chemistry of an aqueous waste stream(s). Before an aqueous waste stream is accepted for treatment, the waste is characterized and evaluated. Information from the characterization is used to adjust the treatment process or change the configuration of the 200 Area ETF process units, as necessary, to optimize the treatment process for a particular aqueous waste stream.

Typically, an aqueous waste is processed first in the primary treatment train, where the 200 Area ETF is configured to process an aqueous waste through the UV/OX unit first, followed by the RO unit. However, under an alternate configuration, an aqueous waste could be processed in the RO unit first. For example, high concentrations of nitrates in an aqueous waste might interfere with the performance of the UV/OX. In this case, the 200 Area ETF could be configured to process the waste in the RO unit before the UV/OX unit.

The flexibility of the 200 Area ETF also allows some aqueous waste to be processed in the secondary treatment train first. For example, for small volume aqueous waste with high concentrations of some anions and metals, the approach could be to first process the waste stream in the secondary treatment train. This approach would prevent premature fouling or scaling of the RO unit. The liquid portion (i.e.,-untreated overheads from the ~~200 Area ETF e~~Evaporator Vapor Body Vessel (60IEV-1) and thin film dryer) would be sent to the primary treatment train.

Figures C.4~~C.5~~ and ~~Figure~~ C.5~~C.6~~ provide example process flow diagrams for two different operating configurations.

C.2.3 Primary Treatment Train

The primary treatment train consists of the following processes:

- Influent Receipt/Surge tank - inlet, surge capacity
- Filtration - for suspended solids removal
- UV/OX - organic destruction
- pH adjustment - waste neutralization
- Hydrogen peroxide decomposition - removal of excess hydrogen peroxide
- Degasification - removal of carbon dioxide
- RO - removal of dissolved solids
- IX - removal of dissolved solids
- Verification - holding tanks during verification

Influent Receipt/Surge Tank. Depending on the configuration of the 200 Area ETF, the surge tank is one inlet used to feed an aqueous waste into the 200 Area ETF for treatment. In Configuration 1 (Figure C.4~~C.5~~), the surge tank is the first component downstream of the LERF. The surge tank provides a storage/surge volume for chemical pretreatment and controls feed flow rates from the LERF to the 200 Area ETF. However, in Configuration 2 (Figure C.5~~C.6~~), aqueous waste from LERF is fed directly into the treatment units. In this configuration, the surge tank receives aqueous waste, which has been processed in the RO units, and provides the feed stream to the remaining downstream process units. In yet another configuration, some small volume aqueous waste could be received into the secondary treatment train first for processing. In this case, the aqueous waste would be received directly into the secondary waste receiving tanks. Finally, the surge tank also receives waste extracted from various systems within the primary and secondary treatment train while in operation.

The surge tank is located outside building 2025-E ~~the 200 Area ETF~~ on the south side. In the surge tank (Figure C.6~~C.7~~), the pH of an aqueous waste is adjusted using the metered addition of sulfuric acid and sodium hydroxide, as necessary, to prepare the waste for treatment in downstream processes. In addition, hydrogen peroxide or biocides could be added to control biological growth in the surge tank. A pump recirculates the contents in the surge tank, mixing the chemical reagents with the waste to a uniform pH.

Filtration. Two primary filter systems remove suspended particles in an aqueous waste: a rough filter removes the larger particulates, while a fine filter removes the smaller particulates. The location of these filters depends on the configuration of the primary treatment train. However, the filters normally are located upstream of the RO units.

The solids accumulating on these filter elements are backwashed to the secondary waste receiving tanks with pulses of compressed air and water, forcing water back through the filter. The backwash operation is initiated either automatically by a rise in differential pressure across the filter or manually by an operator. The filters are cleaned chemically when the backwashing process does not facilitate acceptable filter performance.

Auxiliary fine and rough filters (e.g., disposable filters) have been installed to provide additional filtration capabilities. Depending on the configuration of the 200 Area ETF, the auxiliary filters are operated either in series with the primary filters to provide additional filtration or in parallel, instead of the primary fine and rough filters, to allow cleaning/maintenance of the primary fine and rough filters while the primary treatment train is in operation.

Ultraviolet Light/Oxidation. Organic compounds contained in an aqueous waste stream are destroyed in the UV/OX system (Figure C.7~~C.8~~). Hydrogen peroxide is mixed with the waste. The UV/OX system uses the photochemical reaction of UV light on hydrogen peroxide to form hydroxyl radicals and other

reactive species that oxidize the organic compounds. The final products of the complete reaction are carbon dioxide, water, and inorganic ions.

Organic destruction is accomplished in two UV/OX units operating in parallel. During the UV/OX process, the aqueous waste passes through reaction chambers where hydrogen peroxide is added. While in the UV/OX system, the temperature of an aqueous waste is monitored. Heat exchangers are used to reduce the temperature of the waste should the temperature of the waste approach the upper limits for the UV/OX or RO systems.

pH Adjustment. The pH of a waste stream is monitored and controlled at different points throughout the treatment process. Within the primary treatment train, the pH of a waste can be adjusted with sulfuric acid or sodium hydroxide to optimize operation of downstream treatment processes or adjusted before final discharge. For example, the pH of an aqueous waste would be adjusted in the pH adjustment tank after the UV/OX process and before the RO process. In this example, pH is adjusted to cause certain chemical species such as ammonia to form ammonium sulfate, thereby increasing the rejection rate of the RO.

Hydrogen Peroxide Decomposition. Typically, hydrogen peroxide added into the UV/OX system is not consumed completely by the system. Because hydrogen peroxide is a strong oxidizer, the residual hydrogen peroxide from the UV/OX system is removed to protect the downstream equipment. The hydrogen peroxide decomposer uses a catalyst to break down the hydrogen peroxide that is not consumed completely in the process of organic destruction. The aqueous waste is sent through a column that breaks down the hydrogen peroxide into water and oxygen. The gas generated by the decomposition of the hydrogen peroxide is vented to the vessel off gas system.

Degasification. The degasification column is used to purge dissolved carbon dioxide from the aqueous waste to reduce the carbonate loading to downstream dissolved solids removal processes within the 200 Area ETF primary treatment train. The purged carbon dioxide is vented to the vessel off gas system.

Reverse Osmosis (RO). The RO system (Figure C.8~~C.9~~) uses pressure to force clean water molecules through semi-permeable membranes while keeping the larger molecule contaminants, such as dissolved solids, and large molecular weight organic materials, in the membrane. The RO process uses a staged configuration to maximize water recovery. The process produces two separate streams, including a clean 'permeate' and a concentrate (or retentate), which are concentrated as much as possible to minimize the amount of secondary waste produced.

The RO process is divided into first and second stages. Aqueous waste is fed to the first RO stage from the RO feed tank. The secondary waste receiving tanks of the secondary treatment train receive the retentate removed from the first RO stage, while the second RO stage receives the permeate (i.e., 'treated' aqueous waste from the first RO stage). In the second RO stage, the retentate is sent to the first stage RO feed tank while the permeate is sent to the IX system or to the surge tank, depending on the configuration of the 200 Area ETF.

Two support systems facilitate this process. An anti-scale system injects scale inhibitors as needed into the feed waste to prevent scale from forming on the membrane surface. A clean-in-place system using cleaning agents, such as descalants and surfactants, cleans the membrane pores of surface and subsurface deposits that have fouled the membranes.

Ion Exchange. Because the RO process removes most of the dissolved solids in an aqueous waste, the IX process (Figure C.9~~C.10~~) acts as a polishing unit. The IX system consists of three columns containing beds of cation and/or anion resins. This system is designed to allow for regeneration of resins and maintenance of one column while the other two are in operation. Though the two columns generally are operated in series, the two columns also can be operated in parallel or individually.

Typically, the two columns in operation are arranged in a primary/secondary (lead/lag) configuration, and the third (regenerated) column is maintained in standby. When dissolved solids breakthrough the first IX column and are detected by a conductivity sensor, this column is removed from service for

regeneration, and the second column replaces the first column and the third column is placed into service. The column normally is regenerated using sulfuric acid and sodium hydroxide. The resulting regeneration waste is collected in the secondary waste receiving tanks.

Spent resins are transferred into a disposal container should regeneration of the IX resins become inefficient Free water is removed from the container and returned to the surge tank. Dewatered resins are transferred to a final storage/disposal point.

Verification. The three verification tanks (Figure C.~~11~~10) are used to hold the treated effluent while a determination is made that the effluent meets discharge limits. The effluent can be returned to the primary treatment train for additional treatment, or to the LERF, should a treated effluent not meet Waste Discharge Permit ~~or Final Delisting~~ST0004500 requirements.

The three verification tanks alternate between three operating modes: receiving treated effluent, holding treated effluent during laboratory analysis and verification, or discharging verified effluent. Treated effluent may also be returned to the 200 Area ETF to provide 'clean' service water for operational and maintenance functions, e.g., for boiler water and for backwashing the filters. This recycling keeps the quantity of fresh water used to a minimum.

C.2.4 Secondary Treatment Train

The secondary treatment system typically receives and processes the following by-products generated from the primary treatment train: concentrate from the first RO stage, filter backwash, regeneration waste from the ion exchange system, and spillage or overflow received into the process sumps. Depending on the operating configuration, however, some aqueous waste could be processed in the secondary treatment train before the primary treatment train (refer to Figures C.4 and C.5~~ and Figure C.6~~ for example operating configurations).

The secondary treatment train provides the following processes:

- Secondary waste receiving - tank receiving and chemical addition
- Evaporation - concentrates secondary waste streams
- Concentrate staging - concentrate receipt, pH adjustment, and chemical addition
- Thin film drying - dewatering of secondary waste streams
- Container handling - packaging of dewatered secondary waste

Secondary Waste Receiving. Waste to be processed in the secondary treatment train is received into two secondary waste receiving tanks, where the pH can be adjusted with sulfuric acid or sodium hydroxide for optimum evaporator performance. Chemicals, such as reducing agents, may be added to waste in the secondary waste receiving tanks to reduce the toxicity or mobility of constituents in the powder.

Evaporation. The ~~200 Area ETF e~~Evaporator Vapor Body Vessel (60IEV-1) is fed alternately by the two secondary waste receiving tanks. One tank serves as a waste receiver while the other tank is operated as the feed tank. The ~~200 Area ETF e~~Evaporator Vapor Body ~~v~~Vessel (also referred to as the vapor body) is the principal component of the evaporation process (Figure C.11~~12~~).

Feed from the secondary waste receiving tanks is pumped through a heater to the recirculation loop of the 200 Area ETF ~~e~~Evaporator. In this loop, concentrated waste is recirculated from the ~~200 Area ETF e~~Evaporator Vapor Body Vessel, to a heater, and back into the evaporator where vaporization occurs. As water leaves the evaporator system in the vapor phase, the concentration of the waste in the evaporator increases. When the concentration of the waste reaches the appropriate density, a portion of the concentrate is pumped to one of the concentrate tanks.

The vapor that is released from the ~~200 Area ETF e~~Evaporator Vapor Body Vessel is routed to the entrainment separator, where water droplets and/or particulates are separated from the vapor. The 'cleaned' vapor is routed to the vapor compressor and converted to steam. The steam from the vapor compressor is sent to the heater (reboiler) and used to heat the recirculating concentrate in the ~~200 Area~~

~~ETF e~~Evaporator Vapor Body Vessel. From the heater, the steam is condensed and fed to the distillate flash tank, where the saturated condensate received from the heater drops to atmospheric pressure and cools to the normal boiling point through partial flashing (rapid vaporization caused by a pressure reduction). The resulting distillate is routed to the surge tank. The non-condensable vapors, such as air, are vented through a vent gas cooler to the vessel off gas system.

Concentrate Staging. The concentrate tanks make up the head end of the thin film drying process. From the ~~200 Area ETF e~~Evaporator Vapor Body Vessel, concentrate is pumped into two concentrate tanks, and pH adjusted chemicals, such as reducing agents, may be added to reduce the toxicity or mobility of constituents when converted to powder. Waste is transferred from the concentrate tanks to the thin film dryer for conversion to a powder. The concentrate tanks function alternately between concentrate receiver and feed tank for the thin film dryer. However, one tank may serve as both concentrate receiver and feed tank.

Because low solubility solids (i.e., calcium and magnesium sulfate) tend to settle in the concentrate tanks, these solids must be removed to prevent fouling and to protect the thin film dryer, and to maintain concentrate tank capacity.

Thin Film Drying. From the concentrate tanks, feed is pumped to the thin film dryer (Figure C.12~~C.13~~) that is heated by steam. As the concentrated waste flows down the length of the dryer, the waste is dried. The dried film, or powder, is scraped off the dryer cylinder by blades attached to a rotating shaft. The powder is funneled through a cone-shaped powder hopper at the bottom of the dryer and into the Container Handling System.

Overhead vapor released by the drying of the concentrate is condensed in the distillate condenser. Excess heat is removed from the distillate by a water-cooled heat exchanger. Part of the distillate is circulated back to the condenser spray nozzles. The remaining distillate is pumped to the surge tank. Any noncondens~~i~~able vapors and particulates from the spray condenser are exhausted to the vessel off gas system.

Container Handling. Before an empty container is moved into the Container Handling System (Figure C.13~~14~~), the lid is removed and the container is placed on a conveyor. The containers are moved into the container filling area after passing through an air lock. The empty container is located under the thin film dryer, and raised into position. The container is sealed to the thin film dryer and a rotary valve begins the transfer of powder to the empty container. Air displaced from the container is vented to the distillate condenser attached to the ~~200 Area ETF e~~Evaporator Vapor Body Vessel that exhausts to the vessel off gas system.

The container is filled to a predetermined level, then lowered from the thin film dryer and moved along a conveyor. The filled container is manually recapped, and moved along the conveyor to the airlock. At the airlock, the container is moved onto the conveyor by remote control. The airlock is opened, the smear sample (surface wipe) is taken, and the contamination level counted. A 'C' ring is installed to secure the container lid. If the container has contaminated material on the outside, the container is wiped down and retested. Filled containers that pass the smear test are labeled, placed on pallets, and moved by forklift to the filled container storage area. Section C.3 provides a more detailed discussion of container handling.

C.2.5 Other 200 Area Effluent Treatment Facility Systems

The 200 Area ETF is provided with support systems that facilitate treatment in the primary and secondary treatment trains and that provide for worker safety and environmental protection. An overview of the following systems is provided:

- Monitor and control system
- Vessel off gas system
- Sump collection system
- Chemical injection feed system

- Verification tank recycle system
- Utilities

C.2.5.1 Monitor and Control System

The operation of the 200 Area ETF is monitored and controlled by a centralized computer system (i.e.,-monitor and control system or MCS). The MCS continuously monitors data from various field indicators, such as pH, flow, tank level, temperature, pressure, conductivity, alarm status, and valve switch positions. Data gathered by the MCS enable operations and engineering personnel to document and adjust the operation of the 200 Area ETF.

Emergency communications equipment and warning systems (e.g. fire alarms and evacuation alarms) are included in Addendum J, Contingency Plan. These emergency response notification alarms are monitored continuously at central Hanford Facility locations (e.g. Hanford Fire Station) and do not rely on staff being present in the 200 Area ETF ~~c~~Control ~~r~~Room for notification and response.

C.2.5.2 Vessel Off ~~g~~Gas System

Ventilation for various tanks and vessels is provided through the vessel off gas system. The system includes a moisture separator, duct heater, pre-filter, high-efficiency particulate air filters, carbon absorber (when required to reduce organic emissions), exhaust fans, and ductwork. Gasses ventilated from the tanks and vessels enter the exhaust system through the connected ductwork. The vessel off gas system draws vapors and gasses off the following tanks and treatment systems:

- Surge tank (60A-TK-1)
- Vent gas cooler (off the ~~ETF e~~Evaporator Vapor Body Vessel (60I-EV-1)/distillate flash tank) (60I-TK-2)
- pH adjustment tank (60C-TK-1)
- Concentrate tanks (2025E-60J-TK-1A/ 2025E-60J-TK-1B)
- Degasification system
- First and second RO stages
- Dry powder hopper
- Effluent pH adjustment tank (60C-TK-2)
- Drum capping station
- Secondary waste receiving tanks (60I-TK-1A /60I-TK-1B)
- Distillate condenser (off the thin film dryer)
- Sump tanks 1 and 2

The vessel off gas system maintains a negative pressure with respect to the atmosphere, which produces a slight vacuum within tanks, vessels, and ancillary equipment for the containment of gas vapor. This system also provides for the collection, monitoring, and treatment of confined airborne in-vessel contaminants to preclude over-pressurization. The high-efficiency particulate air filters remove particulates and condensate from the air stream before these are discharged to the heating, ventilation, and air conditioning system.

C.2.5.3 Sump Collection System

Sump ~~t~~Tanks 1 and 2 compose the sump collection system that provides containment of waste streams and liquid overflow associated with the 200 Area ETF processes. The 2025-E ~~p~~Process ~~a~~Area floor is sloped to two separate trenches that each drain to a sump tank located under the floor of building 2025-E~~the 200 Area ETF~~ (Figure C.1~~4~~15). One trench runs the length of the primary treatment train and drains to Sump Tank 2, located underneath the verification tank pump floor. The second trench collects spillage primarily from the secondary treatment train and flows to Sump Tank 1, located near the

~~200 Area ETF e~~Evaporator Vapor Body Vessel. Sump ~~t~~Tanks 1 and 2 are located below floor level (Figure C.1~~4~~15). An eductor in these tanks prevents sludge from accumulating.

C.2.5.4 Chemical Injection Feed System

At several points within the primary and secondary treatment trains, sulfuric acid and sodium hydroxide (or dilute solutions of these reagents) are metered into specific process units to adjust the pH. For example, a dilute solution of 4 percent sulfuric acid and 4 percent sodium hydroxide could be added to the secondary waste receiving tanks to optimize the evaporation process.

C.2.5.5 Verification Tank Recycle System

To reduce the amount of water added to the process, verification tank water (i.e., verified effluent) is recycled throughout the 200 Area ETF process. Tanks and ancillary equipment that use verification tank water include:

- 4 percent H_2SO4 solution tank and ancillary equipment
- 4 percent NaOH solution tank and ancillary equipment
- Clean-in-place tank and ancillary equipment
- IX columns (during resin regeneration)
- ~~200 Area ETF e~~Evaporator Vapor Body Vessel boiler and ancillary equipment
- Thin film dryer boiler and ancillary equipment
- Seal water system.

In addition, verification tank water is used extensively during maintenance activities. For example, it may be used to flush piping systems or to confirm the integrity of piping, a process tank, or tank truck.

C.2.5.6 Utilities

The 200 Area ETF maintains the following utility supply systems required for the operation ~~of the ETF~~:

- Cooling water system - removes heat from process water via heat exchangers and a cooling tower
- Compressed air system - provides air to process equipment and instrumentation
- Seal water system - provides cool, clean, pressurized water to process equipment for pump seal cooling and pump seal lubrication, and provides protection against failure and fluid leakage
- Demineralized water system - removes solids from raw water system to produce high quality, low ion-content, water for steam boilers, and for the hydrogen peroxide feed system.
- Heating, ventilation, and air conditioning system - provides continuous heating, cooling, and air humidity control throughout building 2025-E~~the ETF~~.

The following utilities support 200 Area ETF activities:

- Electrical power
- Sanitary water
- Communication systems
- Raw water

C.3 Containers

This section provides specific information on container storage and treatment operations at the 200 Area ETF, including descriptions of containers, labeling, and secondary containment structures.

Per Addendum A, Part A Form the maximum volume of dangerous and/or mixed waste that can be stored in containers is 147,630 liters (39,000 gallons). A list of dangerous and/or mixed waste managed in containers at the 200 Area ETF is also ~~presented~~ provided in Addendum A, Part A Form. The types of dangerous and/or mixed waste managed in containers in the 200 Area ETF could include:

- Secondary waste powder generated from the treatment process
- Aqueous waste received from other Hanford site sources awaiting treatment
- Miscellaneous waste generated by operations and maintenance activities.

The secondary treatment train processes the waste by-products from the primary treatment train, which are concentrated and dried into a powder. Containers are filled with dry powder waste from the thin film dryer via a remotely controlled system. Containers of aqueous waste received from other Hanford site sources are stored at 200 Area ETF until their contents can be transferred to the process for treatment. The waste is usually transferred to the secondary waste receiving or concentration tanks. Containers at the Load-In Station are transferred into one of the Load-In Station tanks, surge tank, or directly to the LERF. Miscellaneous waste generated from maintenance and operations activities are stored at the 2025-E building~~ETF~~. The waste could include process waste, such as used filter elements; spent RO membranes; damaged equipment, and decontamination and maintenance waste, such as contaminated rags, gloves, and other personal protective equipment. Containers of miscellaneous waste ~~which~~ that have free liquids generally are packaged with absorbents.

Several container collection areas could be located within the 200 Area ETF process and container handling areas. These collection areas are used only to accumulate waste in containers. Once a container is filled, the container is transferred to a container storage area (Figure C.2~~3~~ and Figure C.3~~4~~), to another TSD unit, or to a less-than-90-day storage pad. Containers stored in the additional storage area (Figure C.3~~4~~) are elevated or otherwise protected from contact with accumulated liquids. The 2025-E ~~c~~Container ~~s~~Storage ~~a~~Area ~~within 200 Area ETF~~ is a 22.9 x 8.5-meter (75 x 27.9-foot) room located adjacent to the ~~200 Area ETF p~~2025-E Process ~~a~~Areas. ~~The c~~Containers ~~within the container storage area~~ are clearly labeled, and access to these containers is limited by barriers and by administrative controls. The ~~200 Area ETF~~2025-E floor provides secondary containment, and the ~~200 Area ETF~~ roof and walls protect~~s~~ all containers from exposure to the elements.

Waste also could be placed in containers for treatment as indicated in Addendum A. For example, sludge that accumulates in the bottoms of the process tanks is removed periodically and placed into containers. In this example, the waste is solidified by decanting the supernatant ~~supernate~~ from the container and the remainder of the waste is allowed to evaporate, or absorbents are added, as necessary, to address remaining liquids. Following treatment, this waste either is stored at the 200 Area ETF or transferred to another TSD unit.

C.3.1 Description of Containers

The containers used to collect and store dry powder waste are 208-liter (55-gallon) steel containers. Most of the aqueous waste received at 200 Area ETF, and maintenance and operation waste generated, are stored in 208-liter (55-gallon) steel or plastic containers; however, in a few cases, the size of the container could vary to accommodate the size of a particular waste. For example, some process waste, such as spent filters, might not fit into a 208-liter (55-gallon) container. In the case of spent resin from the IX columns, the resin is dewatered, and could be packaged in a special disposal container. In these few cases, specially sized containers could be required. In all cases, however, only approved containers are used and are compatible with the associated waste. Typically, 208-liter (55-gallon) containers are used for treatment.

Current operating practices indicate the use of new 208-liter (55-gallon) containers that have either a polyethylene liner or a protective coating. Any reused or reconditioned container is inspected for container integrity before use. Overpack containers are available for use with damaged containers. Overpack containers typically are unlined steel or polyethylene.

~~Per Addendum A, a maximum of 147,630 liters of dangerous and/or mixed waste could be stored in containers in the 200 Area ETF.~~

C.3.2 Container Management Practices

Before use, each container is checked for signs of damage such as dents, distortion, corrosion, or scratched coating. For dry powder loading, empty containers on pallets are raised by a forklift and manually placed on the conveyor that transports the containers to the automatic filling station in the container handling room (Figure C.13~~14~~). The container lids are removed and replaced manually following the filling sequence. After filling, containers exit the container handling room via the filled drum conveyor. Locking rings are installed, the container label is affixed, and the container is moved by dolly or forklift to the 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area.

Before receipt at 200 Area ETF, each container from other Hanford site sources is inspected for leaks, signs of damage, and a loose lid. The identification number on each container is checked to ensure the proper container is received. The containers are typically placed on pallets and moved by dolly or forklift to the container storage area. These containers are later moved to the 2025-E ~~p~~Process ~~a~~Area and the contents transferred to the process for treatment.

Containers used for storing maintenance and operations secondary waste are labeled before being placed in the container storage area or in a collection area. Lids are secured on these containers when not being filled. When the containers in a collection area are full, the containers are transferred by dolly or forklift to the container storage area or to an appropriate TSD unit. Containers used for treating waste also are labeled. The lids on these containers are removed as required to allow for treatment. During treatment, access to these containers is controlled through physical barriers and/or administrative controls.

The filled containers in the container storage areas are inventoried, checked for proper labeling, and placed on pallets or in a separate containment device as necessary. Each pallet is moved by forklift. Within the container storage areas, palletized containers are stacked no more than three pallets high and in rows no more than two containers wide. Unobstructed aisles with a minimum of 76-centimeter (30-inch) aisle space separate rows.

C.3.3 Container Labeling

Labels are affixed on containers used to store dry powder when the containers leave the container handling room. Labels are affixed on other waste containers before use. Every container is labeled with the date that the container was filled. Appropriate major risk labels, such as "corrosive", "toxic", or "F-listed", also are added. Each container also has a label with an identification number for tracking purposes.

C.3.4 Containment Requirements for Managing Containers

Secondary containment is provided in the container management areas within ~~the~~ building 2025-E~~ETF~~. The secondary containment provided for the tank systems also serves the container management areas. This section describes the design and operation of the secondary containment structure for these areas. Section C.2.1, and Section C.4.3.1.2 discuss secondary containment at the Load-In Station.

C.3.4.1 Container Secondary Containment System Design

For the container management areas, in building 2025-E, secondary containment is provided by the trenches, reinforced concrete floor, and a 15.2-centimeter (6-inch) rise (berm) along the walls of the 2025-E Process Area and 2025-E Ceontainer ~~s~~Storage ~~a~~Area ~~of the 200 Area ETF provides secondary containment~~. The engineering assessment required for tanks (*Final RCRA Information Needs Report,* Mausshardt 1995) also describes the design and construction of the secondary containment provided for ~~the 200 Area ETF~~ building 2025-E container management areas. All systems were designed to national codes and standards (e.g., American Society for Testing Materials, American Concrete Institute standards).

The floor is composed of cast-in-place, pre-formed concrete slabs, and has a minimum thickness of 15.2-centimeters (6-inch). All slab joints and floor and wall joints have water stops installed at the mid-depth of the slab. In addition, filler was applied to each joint. The floor and berms are coated with a

chemically resistant; high-solids epoxy coating system consisting of primer and top coating. This coating material is compatible with the waste managed in containers and is an integral part of the secondary containment system for containers.

The floor is sloped to drain any solution in the 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area to floor drains along the west wall. Each floor drain consists of a grating over a 20.3-centimeter (8-inch) diameter drain port connected to a 10.2-centimeter (4-inch) polyvinyl chloride transfer pipe. The pipe passes under this wall and connects to a trench running along the east wall of the adjacent 2025-E ~~p~~Process ~~a~~Area. This trench drains solution to ~~s~~Sump ~~t~~Tank-_1.

The 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area is separated from the 2025-E ~~p~~Process ~~a~~Area by a common wall and a door for access to the two areas (Figure C.2~~3~~). These two areas share a common floor and trenches that, with the 15.2-centimeter (6-inch) rise of the containing walls, form the secondary containment system for the 2025-E ~~p~~Process ~~a~~Area and the 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area.

C.3.4.2 Structural Integrity of Base

Engineering calculations were performed showing the floor of the 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area is capable of supporting the weight of containers. These calculations were reviewed and certified by a professional engineer (*Final RCRA Information Needs Report,* Mausshardt 1995). The concrete was inspected for damage during construction. Cracks were identified and repaired to the satisfaction of the professional engineer. Documentation of these certifications is included in the engineering assessment (*Final RCRA Information Needs Report,* Mausshardt 1995).

C.3.4.3 Containment System Capacity

The 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area is primarily used to store dry powder, aqueous waste awaiting treatment, and maintenance and operation waste. Where appropriate, absorbents are added to fix any trace liquids present. Large volumes of liquid are not stored in the 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area. However, liquids might be present in those containers that are in the treatment process. ~~The maximum volume of waste that can be stored in containers in the container storage area is 147,630 liters.~~

Because they are interconnected by floor drains, both the 2025-E ~~p~~Process ~~a~~Area and the 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area are considered in the containment system capacity. The volume available for secondary containment in the 2025-E ~~p~~Process ~~a~~Area is approximately 68,000 liters (18,000 gallons), as discussed in the engineering assessment (*Final RCRA Information Needs Report,* Mausshardt 1995). Using the dimensions of the 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area (23.6 by 8.5 by 0.15~~2~~ meters [77 by 28 by 0.5 feet]), and assuming that 50 percent of the floor area is occupied by containers, the volume of the 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area is 15,300 liters (4,040 gallons). The 2025-E Truck Bay loading area~~s~~ (see Figure~~s~~ C.2 and C.3~~C.4~~) also provide~~s~~ 10,500 liters (2,700 gallons) of containment as it is connected to the 2025-E Process Area and 2025-E Container Storage Area ~~other two areas~~. The combined volume of the 2025-E Truck Bay loading area~~s~~~~, and~~ 2025-E ~~p~~Process ~~a~~Area (including~~, and~~ the ~~e~~Container ~~h~~Handling Room~~area~~) available for secondary containment, is 93,800 liters (24,810 gallons). This volume is greater than 10 percent of the maximum total volume of containers allowed for storage in the ~~ETF~~ building 2025-E, as discussed previously.

C.3.4.4 Control of Run-on

The container management areas are located within building 2025-E~~the ETF~~, which serves to prevent run-on of precipitation.

C.3.4.5 Removal of Liquids from Containment Systems

The 2025-E ~~e~~Container ~~s~~Storage ~~a~~Area is equipped with drains that route solution to a trench in the 2025-E ~~p~~Process ~~a~~Area, which drains to ~~s~~Sump ~~t~~Tank 1. The sump tanks are equipped with alarms that notify operating personnel that a leak is occurring. The sump tanks also are equipped with pumps to transfer waste to the surge tank or the secondary treatment train. Additional information on removal of liquids is provided in Section C.2, and Section C.4.3.1.2.

C.3.4.6 Prevention of Ignitable, Reactive, and Incompatible Wastes in Containers

Individual waste types (i.e., ignitable, corrosive, and reactive) are stored in separate containers. A waste that could be incompatible with other wastes is separated and protected from the incompatible waste. Incompatible wastes are evaluated using the methodology documented in 40 CFR 264, Appendix V. For example, acidic and caustic wastes are stored in separate containers. Free liquids are absorbed in miscellaneous waste containers that hold incompatible waste. Additionally, 200 Area ETF-specific packaging requirements for these types of waste provide extra containment with each individual container. For example, each item of acidic waste is individually bagged and sealed within a lined container.

C.4 Tank Systems

This section provides specific information on tank systems and process units. This section also includes a discussion on the types of waste to be managed in the tanks, tank design information, integrity assessments, and additional information on the 200 Area ETF tanks that treat and store dangerous and/or mixed waste. The 200 Area ETF dangerous waste tanks are identified in Section C.4.1.1. Table C.5, *200 Area ETF Tank Systems Information*, Table C.6, *200 Area ETF Additional Tank System Information*, and Table C.7, *Ancillary Equipment and Material Data* provides individual tank volumes, dimensions, and construction materials. ~~and t~~The relative locations of the tanks and process units ~~in the 200 Area ETF~~ are presented in Figures C.2 and C.3.

C.4.1 Design Requirements

The following sections provide an overview of the design specifications for the tanks within the 200 Area ETF. A separate discussion on the design of the process units also is provided. In accordance with the new tank system requirements of WAC 173-303-640(3), the following tank components and specifications were assessed:

- Dimensions, capacities, wall thicknesses, and pipe connections
- Materials of construction and linings and compatibility of materials with the waste being processed
- Materials of construction of foundations and structural supports
- Review of design codes and standards used in construction
- Review of structural design calculations, including seismic design basis
- Waste characteristics and the effects of waste on corrosion

This assessment was documented in the *Final RCRA Information Needs Report* (*Final RCRA Information Needs Report*, Mausshardt 1995; the engineering assessment performed for the 200 Area ETF tank systems by an independent professional engineer. A similar assessment of design requirements was performed for Load-~~i~~In Station tanks 59A-TK-109 and 59A-TK-117 and is documented in *200 Area Effluent BAT/AKART Implementation, ETF Truck Load-in Facility, Project W-291H Integrity Assessment Report* (W-291H-IAR, KEH 1995~~1994~~). An assessment was also performed when Load-~~i~~In Station tank 59A-TK-1 was placed into service for receipt of dangerous and mixed wastes. The assessment is documented in the *200 Area Effluent Treatment Facility Purgewater Unloading Facility Tank System Integrity Assessment* (HNF-41604, 2009~~a~~).

The specifications for the preparation, design, and construction of the tank systems at the 200 Area ETF are documented in the *Design Construction Specification, Project C-018H, 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility* (V-C018HC1-001, WHC 1992~~a~~). -The preparation, design, and construction of Load-~~i~~In Station tanks 59A-TK-109 and 59A-TK-117 are provided in the construction specifications in *Project W-291, 200 Area Effluent BAT/AKART Implementation ETF Truck Load-in Facility, Construction Specifications* (*W-291H-C2*, KEH 1994). The preparation, design, and construction of Load-~~i~~In Station tank 59A-TK-1 are documented in *Purgewater Unloading Facility Project Documentation* (HNF-39966, 2009~~b~~).

Most of the tanks in the 200 Area ETF are constructed of stainless steel. According to the design of the 200 Area ETF, it was determined stainless steel would provide adequate corrosion protection for these tanks. Exceptions include Load-~~i~~In Station tank 59A-TK-1, which is constructed of fiberglass-reinforced plastic and the verification tanks, which are constructed of carbon steel with an epoxy coating. The ~~200 Area ETF e~~Evaporator ~~/v~~Vapor ~~b~~Body Vessel (and the internal surfaces of the thin film dryer) is constructed of a corrosion resistant alloy, known as alloy 625, to address the specific corrosion concerns in the secondary treatment train. Finally, the hydrogen peroxide decomposer vessels are constructed of carbon steel and coated with a vinyl ester lining.

The shell thicknesses of the tanks identified in Table C.5 represent a nominal thickness of a new tank when placed into operation. The tank capacities identified in this table represent the maximum volumes. Nominal tank volumes discussed below represent the maximum volume in a tank unit during normal operations.

C.4.1.1 Codes and Standards for Tank System Construction

Specific standards for the manufacture of tanks and process systems installed in the 200 Area ETF are briefly discussed in the following sections. In addition to these codes and industrial standards, a seismic analysis for each tank and process system is required [WAC 173-303-806(4)(a)(xi)]. The seismic analysis was performed in accordance with UCRL-15910, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards*, Section 4 (UCRL 1987). The results of the seismic analyses are summarized in the engineering assessment of the 200 Area ETF tank systems (*Final RCRA Information Needs Report,* Mausshardt 1995).

Storage and Treatment Tanks. The following tanks store and/or treat dangerous waste at the 200 Area ETF.

Tank name	Tank number
Surge tank	2025E-60A-TK-1
pH adjustment tank	2025E-60C-TK-1
Effluent pH adjustment tank	2025E-60C-TK-2
First RO feed tank	2025E-60F-TK-1
Second RO feed tank	2025E-60F-TK-2
Verification tanks (three)	2025E-60H-TK-1A/1B/1C
Secondary waste receiving tanks (two)	2025E-60I-TK-1A/1B
Evaporator ~~(v~~Vapor ~~b~~Body Vessel~~)~~	2025E-601-EV-1
Concentrate tanks (two)	2025E-60J-TK-1A/2025E-60J-TK-1B
Sump tanks (two)	2025E-20B-TK-1/2
Distillate flash tank	2025E-60I-TK-2
Load-~~i~~In Station tanks	2025ED-59A-TK-1/109/117

The relative location of these tanks is presented in Figure C.3. These tanks are maintained at or near atmospheric pressure. The codes and standards applicable to the design, construction, and testing of the above tanks and ancillary piping systems are as follows:

ASME - B31.3	Chemical Plant and Petroleum Refinery Piping (ASME 1990)
ASME Sect. VIII, Division I	Pressure Vessels (*Boiler and Pressure Vessel Code,* ASME 1992~~a~~)
AWS - D1.1	Structural Welding Code - Steel (AWS 1992)
ANSI - B16.5	Pipe Flanges and Flanged Fittings (ANSI 1992)
ASME Sect. IX	Welding and Brazing Qualifications (*Boiler and Pressure Vessel Code,* ASME 1992~~b~~)
API 620	Design and Construction of Large Welded Low Pressure Storage Tanks (API 1990)
AWWA - D100	Welded Steel Tanks for Water Storage (AWWA 1989)

AWWA - D103	——Factory-Coated Bolted Steel Tanks for Water Storage (AWWA 1987)
AWWA - D120	——Thermosetting Fiberglass-Reinforced Plastic Tanks (AWWA 1984)
ASTM-D3299	Filament Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion Resistant Tanks.

The application of these standards to the construction of 200 Area ETF tanks and independent verification of completed systems ensured that the tank and tank supports had sufficient structural strength and that seams and connections were adequate to ensure tank integrity. In addition, each tank met strict quality assurance requirements. Each tank, constructed offsite was tested for integrity and leak tightness before shipment to the Hanford Facility. Following installation, the systems were inspected for damage to ensure against leakage and to verify proper operation. If a tank was damaged during shipment or installation, leak tightness testing was repeated onsite.

C.4.1.2 Design Information for Tanks Located Outside of Building 2025-E~~Effluent Treatment Facility~~

The Load-~~i~~In Station tanks, surge tank, and verification tanks are located outside building 2025-E~~the ETF~~. These tanks are located within concrete structures that provide secondary containment. Table C.5, 200 Area ETF Tank Systems Information, provides individual tank volumes, dimensions, and construction materials for tanks located outside building 2025-E.

Load-In Station Tanks (59A-TK-1/ 59A-TK-109/ 59A-TK-117) and Ancillary Equipment. ~~The~~ ~~l~~Load-~~i~~In Station tanks 59A-TK-109 and ~~-117are heated and constructed of stainless steel, and have a nominal capacity of 31,000 liters. Load-in tank 59A-TK-1 is heated and constructed of fiberglass reinforced plastic and has a nominal capacity of 24,500 liters. Load-in tanks 59A-TK-109 and~~ 59A-TK-~~-~~117 are located outside of the ~~metal~~Load-In Station building while ~~l~~Load-~~i~~In Station tank 59A-TK-~~-~~1 is located inside the Load-In Station building. Load-In Station tanks 59A-TK-109 and 59A-TK-117 are heated. Ancillary equipment includes transfer pumps, filtration systems, a double encased, fiberglass transfer pipeline, level instruments for tanker trucks, and leak detection equipment. From the Load-In Station, aqueous waste can be routed to the surge tank or to the LERF through a double-encased line. ~~The load-in tanks, sump, pumps, and truck pad are all provided with s~~Secondary containment for the Load-In Station tanks is discussed in Section C.4.3.1.2.

Surge Tank (60A-TK-1) and Ancillary Equipment. The surge tank is ~~constructed~~located outside on the south side of ~~stainless steel and has a nominal capacity of 421,000 liters.~~building 2025-E. Ancillary equipment to the surge tank includes two underground double encased (i.e., pipe-within-a-pipe) transfer lines connecting to LERF and three pumps for transferring aqueous waste to the primary treatment train. The surge tank is located at the south end of building 2025-E~~the 200 Area ETF~~. The surge tank is insulated and the contents heated to prevent freezing. Eductors in the tank provide mixing.

Verification Tanks (60H-TK-1A/ 60H-TK-1B/ 60H-TK-1C) and Ancillary Equipment. The verification tanks are located outside and north of building 2025-E~~the ETF. The verification tanks have a nominal capacity of 2,760,000 liters each~~. For support, the tanks have a center post with a webbing of beams that extend from the center post to the sides of the tank. The roof is constructed of epoxy covered carbon steel that is attached to the cross beams of the webbing. The tank floor also is constructed of epoxy covered carbon steel and is sloped. Eductors are installed in each tank to provide mixing.

Ancillary equipment includes a return pump that provides circulation of treated effluent through the eductors. The return pump also recycles effluent back to the 200 Area ETF for retreatment and can provide service water for 200 Area ETF functions. Two transfer pumps are used to discharge treated effluent to SALDS or back to the LERF.

C.4.1.3 Design Information for Tanks Located Inside ~~the Effluent Treatment Facility~~ Building 2025-E

Most of the ~~200 Area ETF~~ tanks and ancillary equipment that store or treat dangerous and/or mixed waste are located within building 2025-E~~the ETF~~. The structure serves as secondary containment for the tank systems. Table C.5, 200 Area ETF Tank Systems Information, provides individual tank volumes, dimensions, and construction materials for tanks located outside building 2025-E.

pH Adjustment Tank (60C-TK-1) and Ancillary Equipment. ~~The pH adjustment tank has a nominal capacity of 16,000 liters.~~ Ancillary equipment for ~~this~~ the pH adjustment tank includes overflow lines to a sump tank and pumps to transfer waste to other units in the main treatment train.

Effluent pH Adjustment Tank (60C-TK-2) and Ancillary Equipment. ~~The~~ Ancillary equipment for the effluent pH adjustment tank ~~has a nominal capacity of 13,700 liters. Ancillary equipment~~ includes overflow lines to a sump tank and pumps to transfer waste to the verification tanks.

First and Second RO~~Reverse Osmosis~~ Feed Tanks and Ancillary Equipment. The first RO feed tank is a vertical, stainless steel tank with a round bottom ~~and has a nominal capacity of 19,700 liters~~. Conversely, the second RO feed tank is a rectangular vessel with the bottom of the tank sloping sharply to a single outlet in the bottom center. ~~The second RO feed tank has a nominal capacity of 7,800 liters.~~ Each RO tank has a pump to transfer waste to the RO arrays. Overflow lines are routed to a sump tank.

Secondary Waste Receiving Tanks (60I-TK-1A/30I-TK-1B) and Ancillary Equipment. Two ~~nominal 69,000-liter~~ secondary waste receiving tanks collect waste from the units in the main treatment train, such as concentrate solution (retentate) from the RO units and regeneration solution from the IX columns. These are vertical, cylindrical tanks with a semi-elliptical bottom and a flat top. Ancillary equipment includes overflow lines to a sump tank and pumps to transfer aqueous waste to the ~~200 Area ETF e~~Evaporator Vapor Body Vessel.

~~Effluent Treatment Facility~~ Evaporator Vapor Body Vessel (2025E-60I-EV-1) and Ancillary Equipment. The ~~200 Area ETF e~~Evaporator Vapor Body Vessel, the principal component of the evaporation process, is a cylindrical pressure vessel with a conical bottom. Aqueous waste is fed into the lower portion of the vessel. The top of the vessel is domed and the vapor outlet is configured to prevent carryover of liquid during the foaming or bumping (violent boiling) at the liquid surface. ~~The 200 Area ERF Evaporator. The 200 Area ETF evaporator has a nominal operating capacity of approximately 18,500 liters~~.

The ~~200 Area ETF e~~Evaporator Vapor Body Vessel includes the following ancillary equipment:

- Preheater
- Recirculation pump
- Waste heater with steam level control tank
- Concentrate transfer pump
- Entrainment separator
- Vapor compressor with silencers
- Silencer drain pump.

Distillate Flash Tank (60I-TK-2) and Ancillary Equipment. The distillate flash tank is a horizontal tank ~~that has a nominal operating capacity of 780 liters~~. Ancillary equipment includes a pump to transfer the distillate to the surge tank for reprocessing.

Concentrate Tanks (2025E-60J-TK-1A and 2025E-60J-TK-1B) and Ancillary Equipment. ~~Each of~~ Ancillary equipment for the two concentrate tanks ~~has an approximate nominal capacity of 22,700 liters. Ancillary equipment~~ includes overflow lines to a sump tank and pumps for recirculation and transfer.

Sump Tanks. Sump ~~t~~Tanks 1 and 2 are located below floor level. Both sump tanks are double-walled, rectangular tanks, placed inside concrete vaults. ~~Both tanks have a working volume of 4,000 liters each.~~

The sump tanks are located in pits below grade to allow gravity drain of solutions to the tanks. Each sump tank has two vertical pumps for transfer of waste to the secondary waste receiving tanks or to the surge tank for reprocessing.

C.4.1.4 Design Information for 200 Area Effluent Treatment Facility Process Units

As with the 200 Area ETF tanks, process units that treat and/or store dangerous and/or mixed waste are maintained at or near atmospheric pressure. These units were constructed to meet a series of design standards, as discussed in the following sections. Table C.6 presents the materials of construction and the ancillary equipment associated with these process units. All piping systems are designed to withstand the effects of internal pressure, weight, thermal expansion and contraction, and any pulsating flow. The design and integrity of these units are presented in the engineering assessment (*Final RCRA Information Needs Report,* Mausshardt 1995).

Filters. The ~~l~~Load-~~i~~In Station fine and rough filter vessels (including the influent and auxiliary filters) are designed to comply with the ASME Section VIII, Division I, Pressure Vessels (*Boiler and Pressure Vessel Code,* ASME 1992~~a~~). The application of these standards to the construction of the 200 Area ETF filter system and independent inspection ensure that the filter and filter supports have sufficient structural strength and that the seams and connections are adequate to ensure the integrity of the filter vessels.

Ultraviolet Oxidation (UV/OX) System. The UV/OX reaction chamber is designed to comply with manufacturers standards.

Degasification System. The codes and standards applicable to the design, fabrication, and testing of the degasification column are identified as follows:

- ASME - B31.3, Chemical Plant and Petroleum Refinery Piping (ASME 1990)
- AWS - D1.1, Structural Welding Code - Steel (AWS 1992)
- ANSI - B16.5, Pipe Flanges and Flanged Fittings (ANSI 1992)

R~~Oeverse Osmosis~~ System. The pressure vessels in the RO unit are designed to comply with ASME Section VIII, Division I, Pressure Vessels (*Boiler and Pressure Vessel Code,* ASME 1992~~a~~), and applicable codes and standards.

Ion Exchange (Polishers). The IX columns are designed in accordance with ASME Section VIII, Division I, Pressure Vessels (*Boiler and Pressure Vessel Code,* ASME 1992~~a~~), and applicable codes and standards. Polisher piping is fabricated of type 304 stainless steel or polyvinyl chloride (PVC) and meets the requirements of ASME B31.3, *Chemical Plant and Petroleum Refinery Piping* (ASME 1990).

~~**Effluent Treatment Facility**~~ **Evaporator Vapor Body Vessel.** The ~~200 Area ETF e~~Evaporator Vapor Body Vessel is designed to meet the requirements of ASME Section VIII, Division I, Pressure Vessels (*Boiler and Pressure Vessel Code,* ASME 1992~~a~~), and applicable codes and standards. The ~~200 Area ETF e~~Evaporator Vapor Body Vessel piping meets the requirements of ASME B31.3, *Chemical Plant and Petroleum Refinery Piping* (ASME 1990).

Thin Film Dryer System. The thin film dryer is designed to meet the requirements of ASME Section VIII, Division I, *Boiler and Pressure Vessels Code* (Pressure Vessels, ASME 1992~~a~~), and applicable codes and standards. The piping meets the requirements of ASME –B31.3, *Chemical Plant and Petroleum Refinery Piping* (ASME 1990).

C.4.1.5 Integrity Assessments

The integrity assessment for 200 Area ETF (*Final RCRA Information Needs Report,* Mausshardt 1995) attests to the adequacy of design and integrity of the tanks and ancillary equipment to ensure that the tanks and ancillary equipment will not collapse, rupture, or fail over the intended life considering intended uses. For the ~~l~~Load-~~i~~In Station tanks, a similar integrity assessment was performed (*200 Area Effluent BAT/AKART Implementation, ETF Truck Load-In Facility, Project W-291H, Integrity Assessment Report* [W-291H-IAR, KEH 1995], and ~~HNF~~*200 Area Effluent Treatment Facility*

Purgewater Unloading Facility Tank System Integrity Assessment [HNF-41604, 2009a]). Specifically, the assessment documents the following considerations:

- Adequacy of the standards used during design and construction of the facility
- Characteristics of the solution in each tank
- Adequacy of the materials of construction to provide corrosion protection from the solution in each tank
- Results of the leak tests and visual inspections

The results of these assessments demonstrate that tanks and ancillary equipment have sufficient structural integrity and are acceptable for storing and treating dangerous and/or mixed waste. The assessments also state that the tanks and building were designed and constructed to withstand a design-basis earthquake. Independent, qualified registered professional engineers certified these tank assessments.

The scope of the 200 Area ETF tank integrity assessment was based on characterization data from process condensate. To assess the effect that other aqueous waste might have on the integrity of the 200 Area ETF tanks, the chemistry of an aqueous waste will be evaluated for its potential to corrode a tank (e.g., chloride concentrations will be evaluated). The tank integrity assessment for the Load-In Station tanks (59A-TK-109/59A-TK-117) was based on characterization data from several aqueous waste streams. The chemistry of an aqueous waste stream not considered in the Load-In Station tank integrity assessment also will be evaluated for the potential to corrode a Load-In Station tank.

Consistent with the recommendations of the integrity assessment, a corrosion inspection program was developed. Periodic integrity assessments are scheduled for those tanks predicted to have the highest potential for corrosion. These inspections are scheduled annually or longer, based on age of the tank system, materials of construction, characteristics of the waste, operating experience, and recommendations of the initial integrity assessment. These 'indicator tanks' include the concentrate tanks, secondary waste receiving tanks, and verification tanks. One of each of these tanks will be inspected yearly to determine if corrosion or coating failure has occurred. Should significant corrosion or coating failure be found, an additional tank of the same type would be inspected during the same year. In the case of the verification tanks, if corrosion or coating failure is found in the second tank, the third tank also will be inspected. If significant corrosion were observed in all three sets of tanks, the balance of the 200 Area ETF tanks would be considered for inspection. For tanks predicted to have lower potential for corrosion, inspections also are performed nonroutinely as part of the corrective maintenance program.

C.4.2 Additional Requirements for New Tanks

Procedures for proper installation of tanks, tank supports, piping, concrete, etc., are included in *Construction Specification, Project C-018H, 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility* (V-C018HC1-001, WHC 1992a). For the Load-In Station tanks (59A-TK-109/59A-TK-117), procedures are included in the construction specifications in *Project W-291, 200 Area Effluent BAT/AKART Implementation ETF Truck Load-in Facility, Construction Specifications* (*W-291H-C2*, KEH 1994) and *Purgewater Unloading Facility Project Documentation* (HNF-39966, 2009b). Following installation, an independent, qualified, registered professional engineer inspected the tanks and secondary containment. Deficiencies identified included damage to the surge tank, damage to the verification tank liners, and 200 Area ETF secondary containment concrete surface cracking. All deficiencies were repaired to the satisfaction of the engineer. The tanks and ancillary equipment were leak tested as part of acceptance of the system from the construction contractor. Information on the inspections and leak tests are included in the engineering assessment (*Final RCRA Information Needs Report*, Mausshardt 1995). No deficiencies were identified during installation of the Load-In Station tanks and ancillary equipment.

C.4.3 Secondary Containment and Release Detection for Tank Systems

This section describes the design and operation of secondary containment and leak detection systems at the 200 Area ETF.

C.4.3.1 Secondary Containment Requirements for All Tank Systems

The specifications for the preparation, design, and construction of the secondary containment systems at the 200 Area ETF are documented in *Design Construction Specification, Project C-018H, 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility* (V-C018HC1-001, WHC 1992~~a~~). The preparation, design, and construction of the secondary containment for the ~~l~~Load-~~i~~In Station tanks (59A-TK-109/59A-TK-117) are provided in the construction specifications (*200 Area Effluent BAT/AKART Implementation ETF Truck Load-In Facility, Construction Specifications, [W-291H-C2,* KEH 1994], and *Purgewater Unloading Facility Project Documentation* [HNF-39966, 2009]~~b~~). All systems were designed to national codes and standards. Constructing the 200 Area ETF per these specifications ensured that foundations are capable of supporting tank and secondary containment systems and that uneven settling and failures from pressure gradients should not occur.

C.4.3.1.1 Common Elements

The following text describes elements of secondary containment that are common to all 200 Area ETF tank systems. Details on the secondary containment for specific tanks, including leak detection systems and liquids removal, are provided in Section C.4.3.1.2.

Foundation and Construction. For the tanks within the 2025-E building~~ETF~~, except for the sump tanks, secondary containment is provided by a coated concrete floor and a 15.2-centimeter (6-inch) rise (berm) along the containing walls. The double-wall construction of the sump tanks provides secondary containment. Additionally, trenches are provided in the floor that also provides containment and drainage of any liquid to a sump pit. For tanks outside building 2025-E~~the ETF~~, secondary containment also is provided with coated concrete floors in a containment pit (~~l~~Load-~~i~~In Station tanks) or surrounded by concrete dikes (the surge tank and verification tanks).

The transfer piping that carries aqueous waste into the 200 Area ETF is pipe-within-a-pipe construction, and is buried approximately 1.2 meters (4 feet) below ground surface. The pipes between the verification tanks and the verification tank pumps within building 2025-E~~the 200 Area ETF~~ are located in a concrete pipe trench.

For this discussion, there are five discrete secondary containment systems associated with the following tanks and ancillary equipment that treat or store dangerous waste:

- Load-~~i~~In Station ~~in~~ tanks
- Surge tank
- 2025-E Process ~~a~~Area ~~(including sump tanks)~~
- Sump tanks
- Verification tanks
- Transfer piping and pipe trenches

All of the secondary containment systems are designed with reinforcing steel and base and berm thickness to minimize failure caused by pressure gradients, physical contact with the waste, and climatic conditions. Classical theories of structural analysis, soil mechanics, and concrete and structural steel design were used in the design calculations for the foundations and structures. These calculations are maintained at the 200 Area ETF. In each of the analyses, the major design criteria from the following documents were included:

V-C018HC1-001, WHC 1992	*Design Construction Specification, Project C-018H, 242A Evaporator/PUREX Plant Process Condensate Treatment Facility* ~~(WHC 1992a)~~
DOE Order 6430.1A	General Design Criteria
HPS-SDC-4.1, Revision 11	"Design Load for Structures," *Hanford Plant Standards* ~~Architectural Civil Design Criteria, Design Loads for Facilities (DOE-RL 1988)~~

UCRL-15910 LLNL 1987	*Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards*, Lawrence Livermore National Laboratory, Livermore, California ~~(UCRL 1987)~~
UBC-91	Uniform Building Code, 1991 Edition (ICBO 1991)
UBC-97	Uniform Building Code, 1997 Edition (ICC 1997, for Load-~~i~~In Station tank 59A-TK-1)

The design and structural analysis calculations substantiate the structural designs in the referenced drawings. The conclusions drawn from these calculations indicate that the designs are sound and that the specified structural design criteria were met. This conclusion is verified in the independent design review that was part of the engineering assessment (*Final RCRA Information Needs Report* [Mausshardt 1995]; *200 Area Effluent BAT/AKART Implementation ETF Truck Load-In Facility, Construction Specifications, [W-291H-C2,* KEH 1994]; and *200 Area Effluent Treatment Facility Purgewater Unloading Facility Tank System Integrity Assessment* [HNF-41604, 2009~~a~~]).

Containment Materials. The concrete floor consists of cast-in-place and preformed concrete slabs. All slab joints and floor and wall joints have water stops installed at the mid-depth of the slab. In addition, filler was applied to each joint.

Except for the sump tank vaults, all of the concrete surfaces in the secondary containment system, including berms, trenches, and pits, are coated with a chemical-resistant, high-solids, epoxy coating that consists of a primer and a top coating. This coating material is compatible with the waste being treated, and with the sulfuric acid, sodium hydroxide, and hydrogen peroxide additives to the process. The coating protects the concrete from contact with any chemical materials that might be harmful to concrete and prevents the concrete from being in contact with waste material. Table C.8 summarizes the specific types of primer and top coats specified for the concrete and masonry surfaces in the 200 Area ETF. The epoxy coating is considered integral to the secondary containment system for the tanks and ancillary equipment.

The concrete containment systems are maintained such that any cracks, gaps, holes, and other imperfections are repaired in a timely manner. Thus, the concrete containment systems do not allow spilled liquid to reach soil or groundwater. There are a number of personnel doorways and vehicle access points into ~~the 200 Area ETF~~ 2025-E ~~p~~Process ~~a~~Areas. Releases of any spilled or leaked material to the environment from these access points are prevented by 15.2-centimeter (6-inch) concrete curbs, sloped areas of the floor (e.g., truck ramp), or trenches.

Containment Capacity and Maintenance. Each of these containment areas is designed to contain more than 100 percent of the volume of the largest tank in each respective system. Secondary containment systems for the surge tank, and the verification tanks, which are outside ~~the ETF~~building 2025-E, also are large enough to include the additional volume from a 25-year, 24-hour storm event; i.e., 5.3 centimeters (2 inches) of precipitation.

Sprinkler System. The sprinkler system within the ~~200 Area ETF~~ building 2025-E supplies firewater protection to the 2025-E ~~p~~Process ~~a~~Area and the 2025-E ~~c~~Container ~~s~~Storage ~~a~~Area. This system is connected to a site wide water supply system and has the capacity to supply sufficient water to suppress a fire ~~at the ETF~~. However, in the event of failure, the sprinkler system can be hooked up to another water source (e.g., tanker truck).

C.4.3.1.2 Specific Containment Systems

The following discussion presents a description of the individual containment systems associated with specific tank systems.

Load-In Station Tank Secondary Containment. The ~~l~~Load-~~i~~In Station tanks 59A-TK-109 and 59A-TK-117 are mounted on a 46-centimeter (18-inch)-thick reinforced concrete slab (Drawing

H-2-817970) outside of the Load-In Station building. Secondary containment is provided by a pit with 30.5-centimeter (12-inch)-thick walls and a floor constructed of reinforced concrete. The ~~l~~Load-~~i~~In Station tank pit is sloped to drain solution to a sump. The depth of the pit varies with the slope of the floor, with an average thickness of about 1.1 meters (3.5 feet). The volume of the secondary containment is about 73,000 liters (19,300 gallons), which is capable of containing the volume of at least one ~~l~~Load-~~i~~In Station tank ~~(i.e., 34,200 liters)~~. Leaks are detected by a leak detector that alarms locally, in the 200-Area ETF ~~e~~Control ~~r~~Room, and by visual inspection of the secondary containment. Alarms are monitored continuously in the 200 Area ETF ~~e~~Control ~~r~~Room during Load-~~i~~In Station transfers and at least daily when there are no Load-~~i~~In Station transfers occurring.

Adjacent to the pit is a 25.4-centimeter (10-inch)-thick reinforced concrete pad that serves as secondary containment for the ~~l~~Load-~~i~~In Station tanker trucks, containers, transfer pumps, and filter system that serve as the first tanker truck unloading bay. The pad is inside the ~~metal~~ Load-~~i~~In Station building 2025-ED and is 15.2 centimeters (6 inches) below grade with north and south walls gently sloped to allow truck access. The pad has a (7.6-centimeter (3-inch) drain-pipe to route waste solution to the adjacent ~~l~~Load-~~i~~In Station tank pit. The bay in the Load-In Station building is sloped to channel spills or leaks from containers to the Load-In Station pit. Table C.8 provides additional information on the ~~The pad does not have~~ protective coating for the concrete pad~~because it would experience excessive wear from the vehicle traffic~~.

Load-~~i~~In Station tank 59A-TK-1 is located on a 25.4-centimeter (10-inch)-thick reinforced concrete slab (Drawing H-2-817970) inside the ~~metal~~ Load-~~i~~In Station building. The tank has a flat bottom ~~which~~ that sits on a concrete slab in the secondary containment. Secondary containment for the tank, filter system, and ~~truck~~ unloading pumps and piping is provided by an epoxy-coated catch basin with a capacity of about 3,400-liters (900 gallons). The catch basin is sloped to route ~~solution~~ leaks and spills from the catch basin through a 15.2-centimeter (6-inch)-wide by ~~14.3~~-22.9-centimeter (9-inch)-deep trench to the adjacent truck unloading pad. This pad drains to the Load-~~i~~In Station ~~tank~~ pit discussed above. The volume of the combined secondary containment of these two systems is greater than 76,400 liters, which is capable of holding the volume of tank 59A-TK-1. ~~(i.e., 26,000 liters).~~

Adjacent to tank 59A-TK-1 catch basin is a 25.4-centimeter (10-inch)-thick reinforced concrete pad that serves as the second tanker truck unloading bay. The pad is inside the metal Load-~~i~~In Station building and has a 2.4-~~meter~~ by 4.~~0~~-meter (8 by 13-feet) shallow, sloping pit to catch leaks during tanker truck unloading. The pit has a maximum depth of 6.~~0~~ centimeters and a 15.2-centimeter (6-inch)-wide by 6.~~0~~-centimeter (2.4-inch)-deep trench to route leaks to the adjacent tank 59A-TK-1 catch basin. ~~The pad does not have protective coating because it would experience excessive wear from the vehicle traffic.~~The bay in the Load-In Station building is sloped to channel spills or leaks from containers to the Load-In Station pit. Coated concrete surfaces are provided for storage and unloading locations where spills and leaks could potentially occur.

Surge Tank Secondary Containment. The surge tank is mounted on a reinforced concrete ringwall. Inside the ringwall, the flat-bottomed tank is supported by a bed of compacted sand and gravel with a high-density polyethylene liner bonded to the ringwall. The liner prevents galvanic corrosion between the soil and the tank. The secondary containment is reinforced concrete with a 15.2-centimeter (6-inch) thick floor and a 20.3-centimeter (8-inch) thick dike. The secondary containment area shares part of the southern wall of the main 2025-E ~~p~~Process ~~a~~Area. The dike ~~extends up~~is 2.9 meters (9.5 feet) tall~~to~~ and provides ~~a containment volume of~~ 856,298~~856,000~~ liters (226,210 gallons) of secondary containment~~for the 462,000-liter surge tank~~.

The floor of the secondary containment slopes to a sump in the northwest corner of the containment area. Leaks into the secondary containment are detected by level instrumentation in the sump, which alarms in the 200 Area ETF ~~e~~Control ~~r~~Room and/or by routine visual inspections. Sump alarms are monitored continuously in the 200 Area ETF ~~e~~Control ~~r~~Room during 200 Area ETF processing operations and at least daily when 200 Area ETF is not processing waste. A sump pump is used to transfer solution in the secondary containment to a sump tank.

2025-E Process Area Secondary Containment. The 2025-E ~~p~~Process ~~a~~Area contains the tanks and ancillary equipment of the primary and secondary treatment trains, and has a jointed, reinforced concrete slab floor. The concrete floor of the 2025-E ~~p~~Process ~~a~~Area and sump tanks provides~~s~~ the secondary containment. This floor is a minimum of 15.2 centimeters (6 inches) thick. With doorsills 15.2 centimeter (6 inches) high, the 2025-E ~~p~~Process ~~a~~Area (including the 2025-E Truck Bay loading area and 2025-E Container Storage Area) has a containment volume of approximately 93,800 liters (24,810 gallons) (see Section C.3.4.3). ~~The largest tanks in the process area are the secondary waste receiving tanks, which each have a maximum capacity of 73,800 liters.~~

The floor of the 2025-E ~~p~~Process ~~a~~Area is sloped to drain liquids to two trenches that drain to ~~a~~ sumps. Each trench is approximately 38.1 centimeters (15 inches) wide with a sloped trough varying from 39.4 to 76.2- centimeters (15.5 to 30 inches) deep. Leaks into the secondary containment are detected by routine visual inspections of the floor area near the tanks, ancillary equipment, and in the trenches.

A small dam was placed in the trench that comes from the thin film dryer room to contain minor liquid spills originating in the dryer room to minimize the spread of contamination into the 2025-E ~~p~~Process ~~a~~Area. The dryer room is inspected for leaks in accordance with the inspection schedule in Addendum I, Inspection Requirements. Operators clean up these minor spills by removing the liquid waste and decontaminating the spill area.

A small dam was also placed in the trench adjacent to the chemical feed skid when the chemical berm area was expanded to accommodate acid and caustic pumps, which were moved indoors from the top of the surge tank to resolve a safety concern. This dam was designed to contain minor spills originating in the chemical berm area and prevent them from entering the process sump.

The northwest corner of the 2025-E ~~p~~Process ~~a~~Area consists of a pump pit containing the pumps and piping for transferring treated effluent from the verification tanks to SALDS. The pit is built 1.37 meters (4.5 feet) below the 2025-E ~~p~~Process ~~a~~Area floor level and is sloped to drain to a trench built along its north wall that routes liquid to ~~s~~Sump ~~t~~Tank 2~~1~~. Leaks into the secondary containment of the pump pit are detected by routine visual inspections.

Sump Tanks. The sump tanks support the secondary containment system, and collect waste from several sources, including:

- 2025-E ~~p~~Process ~~a~~Area drain trenches
- Tank overflows and drains
- Container washing water
- Resin dewatering solution
- Steam boiler blow down
- Sampler system drains.

These double-contained tanks are located within unlined, concrete vaults. The sump tank levels are monitored by remote level indicators or through visual inspections from the sump covers. These indicators are connected to high- and low-level alarms that are monitored in the 200 Area ETF ~~c~~Control ~~r~~Room during ETF processing operations and at least daily when 200 Area ETF is not processing liquid waste. -When a high-level alarm is activated, a pump is activated and the sump tank contents usually are routed to the secondary treatment train for processing. The contents also could be routed to the surge tank for treatment in the primary treatment train. In the event of an abnormally high inflow rate, a second sump pump is initiated automatically.

Verification Tanks Secondary Containment. The three verification tanks (60H-TK-1A /60H-TK-1B/ 60H-TK-1C) are each mounted on ringwalls with high-density polyethylene liners similar to the surge tank. The secondary containment for the three tanks is reinforced concrete with a 15.2-centimeter (6-inch) thick floor and a 20.3-centimeter (8-inch) thick dike. The dike extends up ~~2.6~~ 2.4 meters (8 feet)

to provide a containment of approximately 3,390,000-liters (896,000 gallons) exceeding the capacity of a single verification tank (See Table C.5).

The floor of the secondary containment slopes to a sump along the southern wall of the dike. Leaks into the secondary containment are detected by level instrumentation in the sump and/or by routine visual inspections. Sump alarms are monitored continuously in the 200 Area ETF eControl rRoom during 200 Area ETF processing operations and at least daily when 200 Area ETF is not processing waste. A sump pump is used to transfer solution in the secondary containment to a sump tank.

C.4.3.2 Additional Requirements for Specific Types of Systems

This section addresses additional requirements in WAC 173-303-640 for double-walled tanks like the sump tanks and secondary containment for ancillary equipment and piping associated with the tank systems.

C.4.3.2.1 Double-Walled Tanks

The sump tanks are the only tanks in the 200 Area ETF classified as 'double-walled' tanks. These tanks are located in unlined concrete vaults and support the secondary containment system for the 2025-E pProcess aArea. The sump tanks are equipped with a leak detector between the walls of the tanks that provide continuous monitoring for leaks. The leak detector alarms are monitored in the 200 Area ETF eControl rRoom. These sump tank alarms are monitored continuously during 200 Area ETF processing operations and at least daily when 200 Area ETF is not processing waste. The inner tanks are contained completely within the outer shells. The tanks are contained completely within the concrete structure of building 2025-Ethe 200 Area ETF so corrosion protection from external galvanic corrosion is not necessary.

C.4.3.2.2 Ancillary Equipment

The secondary containment provided for the tanks and process systems also serves as secondary containment for the ancillary equipment associated with these systems.

Ancillary Equipment. Section C.4.3.1.2 describes the secondary containment systems that also serve most of the ancillary equipment within the 200 Area ETF. Between the 200 Area ETF building 2025-E and the verification tanks, a pipeline trench provides secondary containment for four pipelines connecting the transfer pumps (i.e., discharge and return pumps) in the 200 Area ETF with the verification tanks (Figure C.2, Table C.6, and Table C.7). This concrete trench crosses under the road and extends from the verification tank pumps to the verification tanks. Treated effluent flows through these pipelines from the verification tank pumps to the verification tanks. The return pump is used to return effluent to the 200 Area ETF for use as service water or for reprocessing.

For all of the ancillary equipment housed within building 2025-Ethe ETF, the concrete floor, trenches, and berms form the secondary containment system. For the ancillary equipment of the surge tank and the verification tanks, secondary containment is provided by the concrete floors and dikes associated with these tanks. The concrete floor and pit provide secondary containment for the ancillary equipment of the lLoad-iIn Station tanks.

Transfer Piping and Pipe Trenches. The two buried transfer lines between LERF and the surge tank have secondary containment in a pipe-within-a-pipe arrangement. The 10.2-centimeter (4-inch) transfer line has an a 20.3-centimeter (8-inch) outer pipe, while the 7.6-centimeter (3-inch) transfer, line has a 15.2-centimeter (6-inch) outer pipe. The pipes are fiberglass and are sloped towards the surge tank. The outer piping ends with a drain valve in the surge tank secondary containment.

These pipelines are equipped with leak detection located in the annulus between the inner and outer pipes; the leak detection equipment can continuously 'inspect' the pipelines during aqueous waste transfers. The alarms on the leak detection system are monitored in the 200 Area ETF eControl rRoom. The 200 Area ETF eControl rRoom alarms are monitored continuously during aqueous waste transfers between LERF and the 200 Area ETF surge tank, and at least daily when no transfers are occurring. A low-volume air

purge of the annulus is provided to prevent condensation buildup and minimize false alarms by the leak detection system. In the event that these leak detectors are not in service, the pipelines are inspected during transfers by opening a drain valve to check for solution in the annular space between the inner and outer pipe.

The 7.6-centimeter (3-inch) transfer line between the ~~l~~Load-~~i~~In Station tanks and the surge tank has a 15.2 centimeter (6-inch) outer pipe in a pipe-within-a-pipe arrangement. The piping is made of fiberglass-reinforced plastic and slopes towards the ~~l~~Load-~~i~~In Station tank secondary containment pit. The drain valve and leak detection system for the ~~l~~Load-~~i~~In Station tank pipelines are operated similarly to the leak detection system for the LERF to 200 Area ETF pipelines.

As previously indicated, a reinforced concrete pipe trench provides secondary containment for piping under the roadway between the 200 Area ETF and the verification tanks (60H-TK-1A/60H-TK-1B/60H-TK-1C). Three 15.2 centimeter (6-inch) thick reinforced concrete partitions divide the trench into four portions and support metal gratings over the trench. Each portion of the trench is 1.2 meters (4 feet) wide, 0.76 meter (2.5 feet) deep, and slopes ~~T~~to route any solution present to 10.2-centimeter (4-inch) drain lines through the north wall of ~~the ETF~~ building 2025-E. These drain lines route solution to ~~s~~Sump ~~t~~Tank 2 in building 2025-E~~ETF~~. The floor of the pipe trench is 30.5-centimeters (12 inches) thick and the sides are 15.2 centimeters (6 inches) thick. The concrete trenches are coated with water sealant and covered with metal gratings at ground level to allow vehicle traffic on the roadway.

C.4.4 Tank Management Practices

When an aqueous waste stream is identified for treatment or storage at 200 Area ETF, the generating unit is required to characterize the waste. Based on characterization data, the waste stream is evaluated to determine if the stream is acceptable for treatment or storage. Specific tank management practices are discussed in the following sections.

C.4.4.1.1 Rupture, Leakage, Corrosion Prevention

Most aqueous waste streams can be managed such that corrosion would not be a concern. For example, an aqueous waste stream with high concentrations of chloride might cause corrosion problems when concentrated in the secondary treatment train. One approach is to adjust the corrosion control measures in the secondary treatment train. An alternative might be to blend this aqueous waste in a LERF basin with another aqueous waste that has sufficient dissolved solids, such that the concentration of the chlorides in the secondary treatment train would not pose a corrosion concern.

Additionally, the materials of construction used in the tanks systems (Table C.5) make it unlikely that an aqueous waste would corrode a tank. For more information on corrosion prevention, refer to Addendum B, Waste Analysis Plan.

If operating experience suggests that most aqueous waste streams can be managed such that corrosion would not be a concern, operating practices and integrity assessment schedules and requirements will be reviewed and modified as appropriate.

When a leak in a tank system is discovered, the leak is immediately contained or stopped by isolating the leaking component. Following containment, the requirements of WAC 173-303-640(7), incorporated by reference, are followed. These requirements include repair or closure of the tank/tank system component, and certification of any major repairs.

C.4.4.2 Overfilling Prevention

Operating practices and administrative controls used at the 200 Area ETF to prevent overfilling a tank are discussed in the following paragraphs. The 200 Area ETF process is controlled by the MCS. The MCS monitors liquid levels in the 200 Area ETF tanks and has alarms that annunciate on high-liquid level to notify operators that actions must be taken to prevent overfilling of these vessels. As an additional precaution to prevent spills, many tanks are equipped with overflow lines that route solutions to ~~s~~Sump ~~t~~Tanks 1 and 2 to prevent the tank from overflowing into the secondary containment. These tanks include

the pH adjustment tank; RO feed tanks, effluent pH adjustment tank, secondary waste receiving tanks, and concentrate tanks.

The following section discusses feed systems, safety cutoff devices, bypass systems, and pressure controls for specific tanks and process systems.

Tanks. All tanks are equipped with liquid level sensors that give a reading of the tank liquid volume. All of the tanks are equipped further with liquid level alarms that are actuated if the liquid volume is near the tank overflow capacity. In the actuation of the surge tank alarm, a liquid level switch trips, sending a signal to the valve actuator on the tank influent lines, and causing the influent valves to close. To prevent tank overflows when liquid level monitors are out of service, the tank system is placed in a safe configuration by isolating the tank from influent flow until the liquid level monitoring is restored to service or daily sump level readings may be taken for tanks that overflow to Sump Tanks 1 and 2.

The operating mode for each verification tank, i.e., receiving, holding, or discharging, can be designated through the MCS; modes also switch automatically. When the high-level set point on the receiving verification tank is reached, the flow to this tank is diverted and another tank becomes the receiver. The full tank is switched into verification mode. The third tank is reserved for discharge mode.

The liquid levels in the pH adjustment, first and second RO feed, and effluent pH adjustment tanks are maintained within predetermined operating ranges. Should any of these tanks overflow, the excess waste is piped along with any leakage from the feed pumps to a sump tank.

When waste in a secondary waste-receiving tank reaches the high-level set point, the influent flow of waste is redirected to the second tank. In a similar fashion, the concentrate tanks switch receipt modes when the high-level set point of one tank is reached.

Filter Systems. All filters at 200 Area ETF (i.e., the Load-In Station, rough, fine, and auxiliary filter systems) are in leak-tight steel casings. For the rough and fine filters, a high differential pressure, which could damage the filter element, activates a valve that shuts off liquid flow to protect the filter element from possible damage. To prevent a high-pressure situation, the filters are cleaned routinely with pulses of compressed air that force water back through the filter. Cleaning is terminated automatically by shutting off the compressed air supply if high pressure develops. The differential pressure across the auxiliary filters also is monitored. A high differential pressure in these filters would result in a system shutdown to allow the filters to be changed out.

The Load-In Station filtration system has pressure gauges for monitoring the differential pressure across each filter. A high differential pressure would result in discontinuing filter operation until the filter is replaced.

Ultraviolet Light/Oxidation System and Decomposers. A rupture disk on the inlet piping to each of the UV/OX reaction vessels relieves to the pH adjustment tank in the event of excessive pressure developing in the piping system. Should the rupture disk fail, the aqueous waste would trip the moisture sensor, shut down the UV lamps, and close the surge tank feed valve. Also provided is a level sensor to protect UV lamps against the risk of exposure to air. Should those sensors be actuated, the UV lamps would be shut down immediately.

The piping and valving for the hydrogen peroxide decomposers are configured to split the waste flow: half flows to one decomposer and half flows to the other decomposer. Alternatively, the total flow of waste can be treated in one decomposer or both decomposers can be bypassed. A safety relief valve on each decomposer vessel can relieve excess system pressure to a sump tank.

Degasification System. The degasification column is typically supplied aqueous waste feed by the pH adjustment tank feed pump. This pump transfers waste solution through the hydrogen peroxide decomposer, the fine filter, and the degasification column to the first RO feed tank.

The degasification column is designed for operation at a partial vacuum. A pressure sensor in the outlet of the column detects the column pressure. The vacuum in the degasification column is maintained by a

blower connected to the vessel off gas system. The column is protected from extremely low pressure developed by the column blower by the use of an intake vent that is maintained in the open position during operation. The column liquid level is regulated by a flow control system with a high- and low-level alarm. Plate-type heat exchanger cools the waste solution fed to the degasification column.

RO~~Reverse Osmosis~~ System. The flow through the first and second RO stages is controlled to maintain constant liquid levels in the first and second stage RO feed tanks.

Polisher. Typically, two of the three columns are in operation (lead/lag) and the third (regenerated) column is in standby. When the capacity of the resin in the first column is exceeded, as detected by an increase in the conductivity of the column effluent, the third column, containing freshly regenerated IX resin, is brought online. The first column is taken offline, and the waste is rerouted to the second column, and to the third. Liquid level instrumentation and automatically operated valves are provided in the IX system to prevent overfilling.

~~Effluent Treatment Facility~~ Evaporator Vapor Body Vessel. Liquid level instrumentation in the secondary waste receiving tanks is designed to preclude a tank overflow. A liquid level switch actuated by a high-tank liquid level causes the valves to reposition, closing off flow to the secondary waste receiving tanks. Secondary containment for these tanks routes liquids to a sump tank.

Valves in the ~~200 Area ETF e~~Evaporator Vapor Body Vessel feed line can be positioned to bypass the secondary waste around the ~~200 Area ETF e~~Evaporator Vapor Body Vessel and to transfer the secondary waste to the concentrate tanks (2025E-60J-TK-1A/2025E-60J-TK-1B).

Thin Film Dryer. The two concentrate tanks alternately feed the thin film dryer. Typically, one tank serves as a concentrate waste receiver while the other tank serves as the dryer feed tank. One tank may serve as both concentrate waste receiver and dryer feed tank. Liquid level instrumentation prevents tank overflow by diverting the concentrate flow from the full concentrate tank to the other concentrate tank. Secondary containment for these tanks routes liquids to a sump tank.

An alternate route is provided from the concentrate receiver tank to the secondary waste receiving tanks. Dilute concentrate in the concentrate receiver tank can be reprocessed through the ~~200 Area ETF~~ ~~e~~Evaporator Vapor Body Vessel by transferring the concentrate back to a secondary waste-receiving tank.

C.4.5 Labels or Signs

Each tank or process unit in the 200 Area ETF is identified by a nameplate attached in a readily visible location. Included on the nameplate are the equipment number and the equipment title. Those tanks that store or treat dangerous waste at the 200 Area ETF (Section C.4.1.1) are identified with a label, which reads *PROCESS WATER/WASTE*. The labels are legible at a distance of at least fifty feet or as appropriate for legibility within the 200 Area ETF. Additionally, these tanks bear a legend that identifies the waste in a manner, which adequately warns employees, emergency personnel, and the public of the major risk(s) associated with the waste being stored or treated in the tank system(s).

Caution plates are used to show possible hazards and warn that precautions are necessary. Caution signs have a yellow background and black panel with yellow letters and bear the word *CAUTION*. Danger signs show immediate danger and signify that special precautions are necessary. These signs are red, black, and white and bear the word *DANGER*.

Tanks and vessels containing corrosive chemicals are posted with black and white signs bearing the word *CORROSIVE*. *DANGER - UNAUTHORIZED PERSONNEL KEEP OUT* signs are posted on all exterior doors of building 2025-E~~the ETF~~, and on each interior door leading into the 2025-E ~~p~~Process ~~a~~Area. Tank ancillary piping is also labeled *PROCESS WATER* or *PROCESS LIQUID* to alert personnel which pipes in the 2025-E ~~p~~Process ~~a~~Area contains dangerous and/or mixed waste.

All tank systems holding dangerous waste are marked with labels or signs to identify the waste contained in the tanks. The labels or signs are legible at a distance of at least 15-meters (50-feet) and bear a legend

that identifies the waste in a manner that adequately warns employees, emergency response personnel, and the public, of the major risk(s) associated with the waste being stored or treated in the tank system(s).

C.4.6 Air Emissions

Tank systems that contain extremely hazardous waste that is acutely toxic by inhalation must be designed to prevent the escape of such vapors. To date, no extremely hazardous waste has been managed in 200 Area ETF tanks and is not anticipated. However, the 200 Area ETF tanks have forced ventilation that draws air from the tank vapor spaces to prevent exposure of operating personnel to any toxic vapors that might be present. The vapor passes through a charcoal filter and two sets of high-efficiency particulate air filters before discharge to the environment. The Load-~~i~~In Station tanks and verification tanks are vented to the atmosphere.

C.4.7 Management of Ignitable or Reactive Wastes in Tanks Systems

Although the 200 Area ETF is permitted to accept waste that is designated ignitable or reactive, such waste would be treated or blended immediately after placement in the tank system so that the resulting waste mixture is no longer ignitable or reactive. Aqueous waste received does not meet the definition of a combustible or flammable liquid given in National Fire Protection Association (NFPA) code number 30 (NFPA 1996). The buffer zone requirements in NFPA-30, which require tanks containing combustible or flammable solutions be a safe distance from each other and from public way, are not applicable.

C.4.8 Management of Incompatible Wastes in Tanks Systems

The 200 Area ETF manages dilute solutions that can be mixed without compatibility issues. The 200 Area ETF is equipped with several systems that can adjust the pH of the waste for treatment activities. Sulfuric acid and sodium hydroxide are added to the process through the MCS for pH adjustment to ensure there will be no large pH fluctuations and adverse reactions in the tank systems.

C.5 Surface Impoundments

This section provides specific information on surface impoundment operations at the LERF, including descriptions of the liners and secondary containment structures, as required by WAC 173-303-650 and WAC 173-303-806(4)(d).

The LERF consists of three lined surface impoundments (basins) with a design ~~operating~~ capacity of 29.5 million liters (7.8 million gallons) each. ~~The maximum capacity of each basin is~~ Each basin would overflow when the basin's volume reaches 34 million liters (9 million gallons). The dimensions of each basin at the anchor wall are approximately 103 ~~meters~~ by 85 meters (338 by 278 feet). The typical top dimensions of the wetted area are approximately 89 ~~meters~~ by 71 meters (292 by 233 feet), while the bottom dimensions are approximately 57 by 38 meters (188 by 124 feet). Total depth from the top of the dike to the bottom of the basin is approximately ~~7~~ 8 meters (26.4 feet) at the deepest point. The typical finished basin bottoms lie at about 4.5 meters (15 feet) below the initial grade and ~~175~~ 181 meters (593 feet) above sea level. The dikes separating the basins have a typical height of 3 meters (10 feet) and typical top width of 11.6 meters (38 feet) around the perimeter of the impoundments.

C.5.1 List of Dangerous Waste

A list of dangerous and/or mixed aqueous waste that can be stored in LERF is presented in Addendum A. Addendum B, Waste Analysis Plan also provides a discussion of the types of waste that are managed in the LERF.

C.5.2 Construction, Operation, and Maintenance of Liner System

General information concerning the liner system is presented in the following sections. Information regarding loads on the liner, liner coverage, UV light exposure prevention, and location relative to the water table are discussed.

C.5.2.1 Liner Construction Materials

The LERF employs a double-composite liner system with a leachate detection, collection, and removal system between the primary and secondary liners. Each basin is constructed with an upper or primary liner consisting of a high-density polyethylene geomembrane laid over a bentonite carpet liner. The lower or secondary liner in each basin is a composite of a geomembrane laid over a layer of soil/bentonite admixture with a hydraulic conductivity less than ~~10^{-7}~~ 1.0E-07 centimeters (3.9E-08 inches) per second. The synthetic liners extend up the dike wall to a concrete anchor wall that surrounds the basin at the top of the dike. A batten system bolts the layers in place to the anchor wall (Figure C.15~~16~~).

Figure C.16~~17~~ is a schematic cross-section of the liner system. The liner components, listed from the top to the bottom of the liner system, are the following:

- Primary 60-mil (1.5-millimeter [0.06 inch]) high-density polyethylene geomembrane
- Bentonite carpet liner
- Geotextile
- Drainage gravel (bottom) and geonet (sides)
- Geotextile
- Secondary 60-mil (1.5-millimeter [0.06 inch]) high-density polyethylene geomembrane
- Soil/bentonite admixture (91 centimeters [36 inches] on the bottom, 107 centimeters [42 inches] on the sides)
- Geotextile

The primary geomembrane, made of 60-mil (1.5-millimeter [0.06 inch]) high-density polyethylene, forms the basin surface that holds the aqueous waste. The secondary geomembrane, also 60-mil (1.5-millimeter [0.06 inch]) high-density polyethylene, forms a barrier surface for leachate that might penetrate the primary liner. The high-density polyethylene chemically is resistant to constituents in the aqueous waste and has a relatively high strength compared to other lining materials. The high-density polyethylene resin specified for the LERF contains carbon black, antioxidants, and heat stabilizers to enhance its resistance to the degrading effects of UV light. The approach to ensuring the compatibility of aqueous waste streams with the LERF liner materials and piping is discussed in Addendum B, Waste Analysis Plan.

Three geotextile layers are used in the LERF liner system. The layers are thin, nonwoven polypropylene fabric that chemically is resistant, highly permeable, and resistant to microbiological growth. The first two layers prevent fine soil particles from infiltrating and clogging the drainage layer. The second geotextile also provides limited protection for the secondary geomembrane from the drainage rock. The third geotextile layer prevents the mixing of the soil/bentonite admixture with the much more porous and granular foundation material.

A 30.5-centimeters (12-inch)-thick gravel drainage layer on the bottom of the basins between the primary and secondary liners provides a flow path for liquid to the leachate detection, collection, and removal system. A geonet (or drainage net) is located immediately above the secondary geomembrane on the basin sidewalls. The geonet functions as a preferential flow path for liquid between the liners, carrying liquid down to the gravel drainage layer and subsequently to the leachate sump. The geonet is a mesh made of high-density polyethylene, with approximately 13-millimeter (0.5-inch) openings.

The soil/bentonite layer is 91 centimeters (36 inches) thick on the bottom of the basins and 107-centimeters (42 inches) thick on the basin sidewalls; its permeability is less than ~~10^{-7}~~ 1.0E-07 centimeters (3.9E-08 inches) per second. This composite liner design, consisting of a geomembrane laid over essentially impermeable soil/bentonite, is considered best available technology for solid waste landfills and surface impoundments. The combination of synthetic and clay liners is reported in the literature to provide the maximum protection from waste migration (*Flexible Membrane Liners for Solid and Hazardous Waste Landfills - A State of the Art Review*, Forseth and Kmet 1983).

A number of laboratory tests were conducted to measure the engineering properties of the soil/bentonite admixture, in addition to extensive field tests performed on three test fills constructed near the LERF site. For establishing an optimum ratio of bentonite to soil for the soil/bentonite admixture, mixtures of various ratios were tested to determine permeability and shear strength. A mixture of 12 percent bentonite was selected for the soil/bentonite liner and tests described in the following paragraphs demonstrated that the admixture meets the desired permeability of less than ~~10-7~~1.0E-07 centimeters (3.9E-08 inches) per second. Detailed discussion of test procedures and results is provided in *Report of Geotechnical Investigation, 242-A Evaporator and PUREX Interim Storage Basins, W-105, Project Number 90-1901* (Chen-Northern 1990).

Direct shear tests were performed according to ASTM D3080 test procedures (*Standard Test Method for Direct Shear Test of Soils Under Consolidation Drained Conditions,* ASTM 1990) on soil/bentonite samples of various ratios. Based on these results, the conservative minimum Mohr-Coulomb shear strength value of 30 degrees was estimated for a soil/bentonite admixture containing 12 percent bentonite.

The high degree of compaction of the soil/bentonite layer [92 percent per ASTM D1557 (*Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 feet-pound/feet),* ASTM 1991)] was expected to maximize the bonding forces between the clay particles, thereby minimizing moisture transport through the liner. With respect to particle movement ('piping'), estimated fluid velocities in this low-permeability material are too low to move the soil particles. Therefore, piping is not considered a problem.

For the soil/bentonite layer, three test fills were constructed to demonstrate that materials, methods, and procedures used would produce a soil/bentonite liner that meets the EPA permeability requirement of less than ~~10^{-7}~~1.0E-07 centimeters (3.9E-08 inches) per second. All test fills met the EPA requirements. A thorough discussion of construction procedures, testing, and results is provided in *Report of Permeability Testing, Soil-bentonite Test Fill, KEH W-105, Project No 86-19005* (Chen-Northern 1991~~a~~).

The aqueous waste stored in the LERF is typically a dilute mixture of organic and inorganic constituents. Though isolated instances of soil liner incompatibility have been documented in the literature (*Flexible Membrane Liners for Solid and Hazardous Waste Landfills - A State of the Art Review,* Forseth and Kmet 1983), these instances have occurred with concentrated solutions that were incompatible with the geomembrane liners in which the solutions were contained. Considering the dilute nature of the aqueous waste that is and will be stored in LERF and the moderate pH, and test results demonstrating the compatibility of the high-density polyethylene liners with the aqueous waste ~~[~~(9090 Test Results ~~([~~WHC-SD-W105-TD-001, 1991~~)]~~]), gross failure of the soil/bentonite layer is not probable.

Each basin also is equipped with a floating very low-density polyethylene cover. The cover is anchored and tensioned at the concrete wall at the top of the dikes, using a patented mechanical tensioning system. Figure C.15~~C.16~~ depict the tension mechanism and the anchor wall at the perimeter of each basin. Additional information on the cover system is provided in Section C.5.2.5.

C.5.2.1.1 Material Specifications

Material specifications for the liner system and leachate collection system, including liners, drainage gravel, and drainage net are discussed in the following sections. Material specifications are documented in the *Final Specifications 242-A Evaporator and PUREX Interim Retention Basins* (W-105/83360/ER-0156, KEH 1990~~a~~) and *Construction Specifications for 242-A Evaporator and PUREX Interim Retention Basins* (W-105, KEH 1990~~b~~).

Geomembrane Liners. The high-density polyethylene resin for geomembranes for the LERF meets the material specifications listed in Table C.9. Key physical properties include thickness (60-mil [1.5-millimeters] [0.06-inch] ~~[60-mil]~~) and impermeability (hydrostatic resistance of over ~~360,000~~ 316,000 kilogram per square meter [450 pounds per square inch]). Physical properties meet National Sanitation Foundation Standard 54 (*Flexible Membrane Liners,* NSF 1985). Testing to determine if the

liner material is compatible with typical dilute waste solutions was performed and documented in *9090 Test Results* (WHC-SD-W105-TD-001, 1991).

Soil/Bentonite Liner. The soil/bentonite admixture consists of 11.5 to 14.5 percent bentonite mixed into well-graded silty sand with a maximum particle size of 4.75 millimeters (0.187 inch) (No. 4 sieve). Test fills were performed to confirm the soil/bentonite admixture applied at LERF has hydraulic conductivity less than ~~10^{-7}~~1.0E-07 centimeters (3.9E-08 inches) per second, as required by WAC 173-303-650(2)(j) for new surface impoundments.

Bentonite Carpet Liner. The bentonite carpet liner consists of bentonite (90 percent sodium montmorillonite clay) in a primary backing of woven polypropylene with nylon filler fiber, and a cover fabric of open weave spunlace polyester. The montmorillonite is anticipated to retard migration of solution through the liner, exhibiting a favorable cation exchange for adsorption of some constituents (such as ammonium). Based on composition of the bentonite carpet and of the type of aqueous waste stored at LERF, no chemical attack, dissolution, or degradation of the bentonite carpet liner is anticipated.

Geotextile. The nonwoven geotextile layers consist of long-chain polypropylene polymers containing stabilizers and inhibitors to make the filaments resistant to deterioration from UV light and heat exposure. The geotextile layers consist of continuous geotextile sheets held together by needle punching. Edges of the fabric are sealed or otherwise finished to prevent outer material from pulling away from the fabric or raveling.

Drainage Gravel. The drainage layer consists of thoroughly washed and screened, naturally occurring rock meeting the size specifications for Grading Number 5 in Washington State Department of Transportation construction specifications (*Standard Specification for Road, Bridge, and Municipal Construction*, WSDOT 1988). The specifications for the drainage layer are given in Table C.10. Hydraulic conductivity tests (*Tests of Drainage Rock for the V797 Project, Hanford, Washington; Tests of Drainage Rock for the W105 Project, Hanford, Washington; Tests of Drainage Rock for the W105 Project, Hanford, Washington, CNI Word Order No. 2527*, Chen-Northern 1992~~a, 1992b, 1992c~~) showed the drainage rock used at LERF met the sieve requirements and had a hydraulic conductivity of at least 1 centimeter (0.4 inches) per second, which exceeded the minimum of at least 0.1 centimeters (0.04 inches) per second required by WAC 173-303-650(2)(j) for new surface impoundments.

Geonet. The geonet is fabricated from two sets of parallel high-density polyethylene strands, spaced 1.3 centimeters (0.5 inches) center-to-center maximum to form a mesh with minimum two strands per 2.54 centimeter (1 inch) in each direction. The geonet is located between the liners on the sloping sidewalls to provide a preferential flow path for leachate to the drainage gravel and subsequently to the leachate sump.

Leachate Collection Sump. Materials used to line the 3~~.0 meter~~ by 1.8~~-meter~~ by 0.30-meter (10 by 6 by 1-feet)-deep leachate sump, at the bottom of each basin in the northwest corner, include [from top to bottom (Figure C.17~~18~~)]:

- 25 millimeter (1 inch) high-density polyethylene flat stock (supporting the leachate riser pipe)
- Geotextile
- 60-mil (1.5-millimeter [0.06 inch]) high-density polyethylene rub sheet
- Secondary composite liner:
  - 60-mil (1.5-millimeter [0.06 inch]) high-density polyethylene geomembrane
  - 91 centimeters (36 inches) of soil/bentonite admixture
  - Geotextile

Specifications for these materials are identical to those discussed previously.

Leachate System Risers. Risers for the leachate system consist of 25.4-centimeter (10-inch) and 10.2-centimeter (4-inch) pipes from the leachate collection sump to the catch basin northwest of each

basin (Figure C.1718). The risers lay below the primary liner in a gravel-filled trench that also extends from the sump to the concrete catch basin (Figure C.1719).

The risers are high-density polyethylene pipes fabricated to meet the requirements in ASTM D1248 (ASTM 1989). The 25.4-centimeter (10-inch) riser pipe is perforated every 20.3 centimeters (8 inches) with 1.3-centimeter (0.5-inch) holes around the diameter. Level sensors and leachate pump are inserted in the 25.4-centimeter (10-inch) riser pipe to monitor and remove leachate from the sump. To prevent clogging of the pump and piping with fine particulate, the end of the riser is encased in a gravel-filled box constructed of high-density polyethylene geonet and wrapped in geotextile. The 10.2-centimeter (4-inch) riser pipe is perforated every 10.2 centimeters (4 inches) with 0.64-centimeter (1/4-inch) holes around the diameter. A level detector is inserted in the 10.2-centimeter (4-inch) riser pipe.

Leachate Pump. A deep-well submersible pump, designed to deliver approximately 110 19 liters (5 gallons) per minute, is installed in the 25.4-centimeter (10-inch) leachate riser in each basin. Wetted parts of the leachate pump are made of 316L stainless steel, providing both corrosion resistance and durability.

C.5.2.1.2 Loads on Liner System

The LERF liner system is subjected to the following types of stresses.

Stresses from Installation or Construction Operations. Contractors were required to submit construction quality control plans that included procedures, techniques, tools, and equipment used for the construction and care of liner and leachate system. Methods for installation of all components were screened to ensure that the stresses on the liner system were kept to a minimum.

Calculations were performed to estimate the risk of damage to the secondary high-density polyethylene liner during construction (*Calculations for Liquid Effluent Retention Facility ~~LERF~~ Part B Permit Application* [HNF-SD-LEF-TI-005, 1997]). The greatest risk expected was from spreading the gravel layer over the geotextile layer and secondary geomembrane. The results of the calculations show that the strength of the geotextile was sufficiently high to withstand the stress of a small gravel spreader driving on a minimum of 15 centimeters (6 inches) of gravel over the geotextile and geomembrane. The likelihood of damage to the geomembrane lying under the geotextile was considered low.

To avoid driving heavy machinery directly on the secondary liner, a 28-meter (90-foot) conveyer was used to deliver the drainage gravel into the basins. The gravel was spread and consolidated by hand tools and a bulldozer. The bulldozer traveled on a minimum thickness of 30.5 centimeters (12 inches) of gravel. Where the conveyer assembly was placed on top of the liner, cribbing was placed to distribute the conveyer weight. No heavy equipment was allowed for use directly in contact with the geomembranes.

Additional calculations were performed to estimate the ability of the leachate riser pipe to withstand the static and dynamic loading imposed by lightweight construction equipment riding on the gravel layer (*Calculations for Liquid Effluent Retention Facility Part B Permit Application,* HNF-SD-LEF-TI-005, 1997). Those calculations demonstrated that the pipe could buckle under the dynamic loading of small construction equipment; therefore, the pipe was avoided by equipment during spreading of the drainage gravel.

Installation of synthetic lining materials proceeded only when winds were less than 24 kilometers (15 miles) per hour, and not during precipitation. The minimum ambient air temperature for unfolding or unrolling the high-density polyethylene sheets was -10°Celsius (C~~,~~) (14°Fahrenheit [F]), and a minimum temperature of 0°C (32°F) was required for seaming the high-density polyethylene sheets. Between shifts, geomembranes and geotextile were anchored with sandbags to prevent lifting by wind. Calculations were performed to determine the appropriate spacing of sandbags on the geomembrane to resist lifting caused by 130-kilometer (80-mile) per hour winds (*Calculations for Liquid Effluent Retention Facility Part B Permit Application,* HNF-SD-LEF-TI-005, 1997). All of the synthetic components contain UV light inhibitors and no impairment of performance is anticipated from the short-

term UV light exposure during construction. Section C.5.2.4 provides further detail on exposure prevention.

During the laying of the soil/bentonite layer and the overlying geomembrane, moisture content of the admixture was monitored and adjusted to ensure optimum compaction and to avoid development of cracks.

C.5.2.1.3 Static and Dynamic Loads and Stresses from the Maximum Quantity of Waste

When a LERF basin is full, liquid depth is approximately ~~6.4~~6.8 meters (22.2 feet). Static load on the primary liner is roughly 6,400 kilograms per square meter (9.1 pounds per square inch). Load on the secondary liner is slightly higher because of the weight of the gravel drainage layer. Assuming a density of 805 kilograms per ~~square~~ cubic meter (50 pounds per cubic foot) for the drainage gravel [conservative estimate based on specific gravity of 2.65 (*Simplified Design of Building Foundations,* Ambrose 1988)], the secondary high-density polyethylene liner carries approximately 7,200 kilograms per square meter (10.2 pounds per square inch) of load when a basin is full.

Side slope liner stresses were calculated for each of the layers in the basin sidewalls and for the pipe trench on the northwest corner of each basin (*Calculations for Liquid Effluent Retention Facility Part B Permit Application,* HNF-SD-LEF-TI-005, 1997). Results of these calculations indicate factors of safety against shear were 1.5 or greater for the primary geomembrane, geotextile, geonet, and secondary geomembrane.

Because the LERF is not located in an area of seismic concern, as identified in Appendix VI of 40 CFR 264 and WAC 173-303-282(6)(a)(I), discussion and calculation of potential seismic events are not required.

C.5.2.1.4 Stresses Resulting from Settlement, Subsidence, or Uplift

Uplift stresses from natural sources are expected to have negligible impact on the liner. Groundwater lies approximately 62 meters (200 feet) below the LERF, average annual precipitation is only 16 centimeters (6.3 inches), and the average unsaturated permeability of the soils near the basin bottoms is high, ranging from about 5.5E-04 ~~x 10~~^{4} centimeters (2.2E-04 inches) per second to about 1 centimeter (0.4 inches) per second (*Additional Information for Project W-105, Part B Permit Application,* Chen-Northern 1991~~b~~). Therefore, no hydrostatic uplift forces are expected to develop in the soil underneath the basins. In addition, the soil under the basins consists primarily of gravel and sand, and contains few or no organic constituents. Therefore, uplift caused by gas production from organic degradation is not anticipated.

Based on the design of the soil-bentonite liner, no structural uplift stresses are present within the lining system (*Additional Information for Project W-105, Part B Permit Application,* Chen-Northern 1991~~b~~).

Regional subsidence is not anticipated because neither petroleum nor extractable economic minerals are present in the strata underlying the LERF basins, nor is karst (erosive limestone) topography present.

Dike soils and soil/bentonite layers were compacted thoroughly and proof-rolled during construction. Calculation of settlement potential showed that combined settlement for the foundation and soil/bentonite layer is expected to be about 2.7 centimeters (1.1 inches). Settlement impact on the liner and basin stability is expected to be minimal (*Additional Information for Project W-105, Part B Permit Application,* Chen-Northern 1991~~b~~).

C.5.2.1.5 Internal and External Pressure Gradients

Pressure gradients across the liner system from groundwater are anticipated to be negligible. The LERF is about 62 meters (200 feet) above the seasonal high water table, which prevents buildup of water pressure below the liner. The native gravel foundation materials of the LERF are relatively permeable and free draining. The 2 percent slope of the secondary liner prevents the pooling of liquids on top of the secondary liner. Finally, the fill rate of the basins is slow enough (average 190 liters [50 gallons] per minute) that the load of the liquid waste on the primary liner is gradually and evenly distributed.

To prevent the buildup of gas between the liners, each basin is equipped with 21 vents in the primary geomembrane located above the maximum water level that allow the reduction of any excess gas pressure. Gas passing through these vents exit through a single pipe that penetrates the anchor wall into a carbon adsorption filter. This filter extracts nearly all of the organic compounds, ensuring that emissions to the air from the basins are not toxic.

C.5.2.2 Liner System Location Relative to High-Water Table

The lowest point of each LERF basin is the northwest corner of the sump, where the typical subgrade elevation is 175 meters (574 feet) above mean sea level. Based on data collected from the groundwater monitoring wells at the LERF site, the seasonal high-water table is located approximately 62 meters (200 feet) or more below the lowest point of the basins. This substantial thickness of unsaturated strata beneath the LERF provides ample protection to the liner from hydrostatic pressure because of groundwater intrusion into the soil/bentonite layer. Further discussion of the unsaturated zone and site hydrogeology is provided in Addendum D, Groundwater Monitoring Plan.

C.5.2.3 Liner System Foundation

Foundation materials are primarily gravels and cobbles with some sand and silt. The native soils onsite are derived from unconsolidated Holocene sediments. These sediments are fluvial and glaciofluvial sands and gravels deposited during the most recent glacial and postglacial event. Grain-size distributions and shape analyses of the sediments indicate that deposition occurred in a high-energy environment (*Report of Geotechnical Investigation, 242-A Evaporator and PUREX Interim Storage Basins, Hanford Federal Reservation,* W-105, Project No 90-1901, Chen-Northern 1990).

Analysis of five soil borings from the LERF site was conducted to characterize the natural foundation materials and to determine the suitability of onsite soils for construction of the impoundment dikes and determine optimal design factors. Well-graded gravel containing varying amounts of silt, sand, and cobbles comprises the layer in which the basins were excavated. This gravel layer extends to depths of 10 to 11 meters (33 to 36 feet) below land surface (*Report of Geotechnical Investigation, 242-A Evaporator and PUREX Interim Storage Basins, Hanford Federal Reservation,* W-105, Project No 90-1901, Chen-Northern 1990). The basins are constructed directly on the subgrade. Excavated soils were screened to remove oversize cobbles (greater than 15 centimeters [6 inches] in the largest dimension) and used to construct the dikes.

Settlement potential of the foundation material and soil/bentonite layer was found to be low. The foundation is comprised of undisturbed native soils. The bottom of the basin excavation lies within the well-graded gravel layer, and is dense to very dense. Below the gravel is a layer of dense to very dense poorly graded and well-graded sand. Settlement was calculated for the gravel foundation soils and for the soil/bentonite layer, under the condition of hydrostatic loading from ~~6.4~~ 6.8 meters (22.2 feet) of fluid depth. The combined settlement for the soils and the soil/bentonite layer is estimated to be about 2.7- centimeters (1.1 inches). This amount of settlement is expected to have minimal impact on overall liner or basin stability (*Additional Information for Project W-105, Part B Permit Application,* Chen-Northern 1991~~b~~). Settlement calculations are provided in *Calculations for Liquid Effluent Retention Facility Part B Permit Application* (HNF-SD-LEF-TI-005, 1997).

The load bearing capacity of the foundation material, based on the soil analysis discussed previously, is estimated at about 48,800 kilograms per square meter (69 pounds per square inch) [maximum advisable presumptive bearing capacity (*Basic Soils Engineering,* Hough 1969)]. Anticipated static and dynamic loading from a full basin is estimated to be less than 9,000 kilograms per square meter (13 pounds per square inch) (Section C.5.2.1.3), which provides an ample factor of safety.

When the basins are empty, excess hydrostatic pressure in the foundation materials under the liner system theoretically could result in uplift and damage. However, because the native soil forming the foundations is unsaturated and relatively permeable, and because the water table is located at a considerable depth beneath the basins, any infiltration of surface water at the edge of the basin is expected to travel

predominantly downward and away from the basins, rather than collecting under the excavation itself. No gas is expected in the foundation because gas-generating organic materials are not present.

Subsidence of undisturbed foundation materials is generally the result of fluid extraction (water or petroleum), mining, or karst topography. Neither petroleum, mineral resources, nor karst are believed to be present in the sediments overlying the Columbia River basalts. Potential groundwater resources do exist below the LERF. Even if these sediments were to consolidate from fluid withdrawal, their depth most likely would produce a broad, gently sloping area of subsidence that would not cause significant strains in the LERF liner system. Consequently, the potential for subsidence related failures are expected to be negligible.

Borings at the LERF site, and extensive additional borings in the 200 East Area, have not identified any significant quantities of soluble materials in the foundation soil or underlying sediments (~~Last et al.~~ *Hydrogeology of the 200 Are Low-Level Burial Grounds - An Interim* Report, PNL-6820, 1989). Consequently, the potential for sinkholes is considered negligible.

C.5.2.4 Liner System Exposure Prevention

Both primary and secondary geomembranes and the floating cover are stabilized with carbon black to prevent degradation from UV light. Furthermore, none of the liner layers experience long-term exposure to the elements. During construction, thin polyethylene sheeting was used to maintain optimum moisture content and provide protection from the wind for the soil/bentonite layer until the secondary geomembrane was laid in place. The secondary geomembrane was covered by the geonet and geotextile as soon as quality control testing was complete. Once the geotextile layer was completed, drainage material immediately was placed over the geotextile. The final (upper) geotextile layer was placed over the drainage gravel and immediately covered by the bentonite carpet liner. This was covered immediately, in turn, by the primary high-density polyethylene liner.

Both high-density polyethylene liners, geotextile layers, and geonet are anchored permanently to a concrete wall at the top of the basin berm. During construction, liners were held in place with many sandbags on both the basin bottoms and side slopes to prevent wind from lifting and damaging the materials. Calculations were performed to determine the amount of fluid needed in a basin to prevent wind lift damage to the primary geomembrane. Approximately 15 to 20 centimeters (6 to 8 inches) of solution are kept in each basin to minimize the potential for uplifting the primary liner (*Calculations for Liquid Effluent Retention Facility Part B Permit Application,* HNF-SD-LEF-TI-005, 1997).

The entire lining system is covered by a very low-density polyethylene floating cover that is bolted to the concrete anchor wall. The floating cover prevents evaporation and intrusion from dust, precipitation, vegetation, animals, and birds. A patented tensioning system is employed to prevent wind from lifting the cover and automatically accommodate changes in liquid level in the basins. The cover tension mechanism consists of a cable running from the flexible geosynthetic cover over a pulley on the tension tower (located on the concrete anchor wall) to a dead man anchor. These anchors (blocks) simply hang from the cables on the exterior side of the tension towers. The anchor wall also provides for solid attachment of the liner layers and the cover, using a 6.4-millimeter (1/4-inch) batten and neoprene gasket to bolt the layers to the concrete wall, effectively sealing the basin from the intrusion of light, precipitation, and airborne dust (Figure C.15~~16~~).

The floating cover, made of very low-density polyethylene with UV light inhibitors, is not anticipated to experience unacceptable degradation during the service life of the LERF. The very low-density polyethylene material contains carbon black for UV light protection, anti-oxidants to prevent heat degradation, and seaming enhancers to improve its ability to be welded. A typical manufacturer's limited warranty for weathering of very low-density polyethylene products is 20 years (Poly America, undated). This provides a margin of safety for the anticipated medium-term use of the LERF for aqueous waste storage.

The upper 3.4 to 4.6 meters (11 to 15 feet) of the sidewall liner also could experience stresses in response to temperature changes. Accommodation of thermal influences for the LERF geosynthetic layers is affected by inclusion of sufficient slack as the liners were installed. Calculations demonstrate that approximately 67 centimeters (2.2 feet) of slack is required in the long basin bottom dimension, 46- centimeters (1.5 feet) across the basin, and 34 centimeters (1.1 feet) from the bottom of the basin to the top of the basin wall (*Calculations for Liquid Effluent Retention Facility Part B Permit Application,* HNF-SD-LEF-TI-005, 1997).

Thermal stresses also are experienced by the floating cover. As with the geomembranes, sufficient slack was included in the design to accommodate thermal contraction and expansion.

C.5.2.4.1 Liner Repairs During Operations

Should repair of a basin liner be required while the basin is in operation, a sufficient quantity of the basin contents will be transferred to the 200 Area ETF or another available basin~~.~~ to allow access for the repair activities. After the liner around the leaking or damaged section is cleaned, repairs to the geomembrane will be made ~~by the application of a piece of high-density polyethylene sheeting, sufficient in size to extend approximately 8 to 15 centimeters beyond the damaged area, or~~ as recommended by the liner vendor~~. A round~~ or ~~oval patch will be installed using the same type of equipment and criteria used for the initial field installations~~others knowledgeable in liner repair;~~,~~ such as a professional engineer that has adequate knowledge and experience to make recommendations in liner repairs. The criteria for selecting a person or company to make liner repair recommendations is determined by the Permittees for the LERF basins. Selection criteria could include educational background, related experience, and professional qualifications.

C.5.2.4.2 Control of Air Emissions

The floating covers limit evaporation of aqueous waste and releases of volatile organic compounds into the atmosphere. To accommodate volumetric changes in the air between the fluid in the basin and the cover, and to avoid problems related to 'sealing' the basins too tightly, each basin is equipped with a carbon filter breather vent system. Any air escaping from the basins must pass through this vent, consisting of a pipe that penetrates the anchor wall and extends into a carbon adsorption filter unit.

C.5.2.5 Liner Coverage

The liner system covers the entire ground surface that underlies the retention basins. The primary liner extends up the side slopes to a concrete anchor wall at the top of the dike encircling the entire basin (Figure C.15~~16~~).

C.5.3 Prevention of Overtopping

Overtopping prevention is accomplished through administrative controls and liquid-level instrumentation installed in each basin. The instrumentation includes local liquid-level indication as well as remote indication at the 200 Area ETF. Before an aqueous waste is transferred into a basin, administrative controls are implemented to ensure overtopping will not occur during the transfer. The volume of feed to be transferred is compared to the available volume in the receiving basin. The transfer is not initiated unless there is sufficient volume available in the receiving basin or a cut-off level is established. The transfer into the basin would be stopped when this cut-off level is reached.

In the event of a 25-year, 24-hour storm event, precipitation would accumulate on the basin covers. Through the self-tensioning design of the basin covers and maintenance of adequate freeboard, all accumulated precipitation would be contained on the covers and none would flow over the dikes or anchor walls. The 25-year, 24-hour storm is expected to deliver 5.3 centimeters (2.1 inches) of rain or approximately 0.61 ~~centi~~meters~~s~~ (2 feet) of snow. Cover specifications include the requirement that the covers be able to withstand the load from this amount of precipitation. Because the cover floats on the surface of the fluid in the basin, the fluid itself provides the primary support for the weight of the accumulated precipitation. Through the cover self-tensioning mechanism, there is ample 'give' to accommodate the overlying load without overstressing the anchor and attachment points.

Rainwater and snow evaporate readily from the cover, particularly in the arid Hanford Facility climate, where evaporation rates exceed precipitation rates for most months of the year. The black color of the cover further enhances evaporation. Thus, the floating cover prevents the intrusion of precipitation into the basin and provides for evaporation of accumulated rain or snow.

C.5.3.1 Freeboard

Under current operating conditions, 0.61 meter (2 feet) of freeboard is maintained at each LERF basin, which corresponds to an operating level of 6.8 meters (22.2 feet), or operating capacity 29.5 million liters (7.8 million gallons).

C.5.3.2 Immediate Flow Shutoff

The mechanism for transferring aqueous waste is either through pump transfers with on/off switches or through gravity transfers with isolation valves. These methods provide positive ability to shut off transfers immediately in the event of overtopping. Overtopping a basin during a transfer is very unlikely because the low flow rate into the basin provides long response times. At a flow rate of 284 liters (75 gallons) per minute, approximately 11 days would be required to fill a LERF basin from the ~~6.8-meter~~maximum operating level to overflow level~~(i.e., 0.61 meter of freeboard) to maximum capacity of 34 million liters (i.e., the 7.4 meter level)~~.

C.5.3.3 Outflow Destination

Aqueous waste in the LERF is transferred routinely to 200 Area ETF for treatment. However, should it be necessary to immediately empty a basin, the aqueous waste either would be transferred to the 200 Area ETF for treatment or transferred to another basin (or basins), whichever is faster. If necessary, a temporary pumping system may be installed to increase the transfer rate.

C.5.4 Structural Integrity of Dikes

The structural integrity of the dikes was certified attesting to the structural integrity of the dikes, signed by a qualified, registered professional engineer.

C.5.4.1 Dike Design, Construction, and Maintenance

The dikes of the LERF are constructed of onsite native soils, generally consisting of cobbles and gravels. Well-graded mixtures were specified, with cobbles up to 15 centimeters (6 inches) in the largest dimension, but not constituting more than 20 percent of the volume of the fill. The dikes are designed with a 3:1 (3 units horizontal to 1 unit vertical) slope on the basin side, and 2.25:1 on the exterior side. The dikes are approximately 8.2 meters (26.9 feet) high from the bottom of the basin, and 3 meters (10 feet) above grade.

Calculations were performed to verify the structural integrity of the dikes (*Calculations for Liquid Effluent Retention Facility Part B Permit Application*, HNF-SD-LEF-TI-005, 1997). The calculations demonstrate that the structural strength of the dikes is such that, without dependence on any lining system, the sides of the basins can withstand the pressure exerted by the maximum allowable quantity of fluid in the impoundment. The dikes have a factor of safety greater than 2.5 against failure by sliding.

C.5.4.2 Dike Stability and Protection

In the following paragraphs, various aspects of stability for the LERF dikes and the concrete anchor wall are presented, including slope failure, hydrostatic pressure, and protection from the environment.

Failure in Dike/Impoundment Cut Slopes. A slope stability analysis was performed to determine the factor of safety against slope failure. The computer program 'PCSTABL5' from Purdue University, using the modified Janbu Method, was employed to evaluate slope stability under both static and seismic loading cases. One hundred surfaces per run were generated and analyzed. The assumptions used were as follows (*Additional Information for Project W-105, Part B Permit Application*, Chen-Northern 1991~~b~~):

- Weight of gravel: 2,160 kilograms per cubic meter (135 pounds per cubic foot)

- Maximum dry density of gravel: 2,315 kilograms per cubic meter (144.5 pounds per cubic foot)
- Mohr-Coulomb shear strength angle for gravel: minimum 33 degrees
- Weight of soil/bentonite: 1,600 kilograms per cubic meter (100 pounds per cubic foot)
- Mohr-Coulomb shear strength angle for soil/bentonite: minimum 30 degrees
- Slope: 3 horizontal: 1 vertical
- No fluid in impoundment (worst case for stability)
- Soils at in-place moisture (not saturated conditions)

Results of the static stability analysis showed that the dike slopes were stable with a minimum factor of safety of 1.77 (*Additional Information for Project W-105, Part B Permit Application*, Chen-Northern 1991~~b~~).

The standard horizontal acceleration required in the *Hanford Plant Standards*, "Standard Architectural-Civil Design Criteria, Design Loads for Facilities" (HPS-SDC-4.1, DOE-RL 1988), for structures on the Hanford Site is 0.12 g-force. Adequate factors of safety for cut slopes in units of this type generally are considered 1.5 for static conditions and 1.1 for dynamic stability (Site *Investigation Report, Non-Drag-Off Landfill* Site *Low-Level Burial Area No. 5, 200 West Area*, Golder 1989). Results of the stability analysis showed that the LERF basin slopes were stable under horizontal accelerations of 0.10 and 0.15- g-force, with minimum factors of safety of 1.32 and 1.17, respectively (*Additional Information for Project W-105, Part B Permit Application*, Chen-Northern 1991~~b~~). Printouts from the PCSTABL5 program are provided in *Calculations for Liquid Effluent Retention Facility Part B Permit Application* (HNF-SD-LEF-TI-005, 1997).

Hydrostatic Pressure. Failure of the dikes due to buildup of hydrostatic pressure, caused by failure of the leachate system or liners, is very unlikely. The liner system is constructed with two essentially impermeable layers consisting of a synthetic layer overlying a soil layer with low-hydraulic conductivity. It would require a catastrophic failure of both liners to cause hydrostatic pressures that could endanger dike integrity. Routine inspections of the leachate detection system, indicating quantities of leachate removed from the basins, provide an early warning of leakage or operational problems that could lead to excessive hydrostatic pressure. A significant precipitation event (e.g., a 25-year, 24-hour storm) will not create a hydrostatic problem because the interior sidewalls of the basins are covered completely by the liners. The covers can accommodate this volume of precipitation without overtopping the dike (Section C.5.3), and the coarse nature of the dike and foundation materials on the exterior walls provides for rapid drainage of precipitation away from the basins.

Protection from Root Systems. Risk to structural integrity of the dikes because of penetrating root systems is minimal. Excavation and construction removed all vegetation on and around the impoundments, and native plants (such as sagebrush) grow very slowly. The large grain size of the cobbles and gravel used as dike construction material do not provide an advantageous germination medium for native plants. Should plants with extending roots become apparent on the dike walls, the plants will be controlled with appropriate herbicide application.

Protection from Burrowing Mammals. The cobble size materials that make up the dike construction material and the exposed nature of the dike sidewalls do not offer an advantageous habitat for burrowing mammals. Lack of vegetation on the LERF site discourages foraging. The risk to structural integrity of the dikes from burrowing mammals is therefore minimal. Periodic visual inspections of the dikes provide observations of any animals present. Should burrowing mammals be noted onsite, appropriate pest control methods such as trapping or application of rodenticides will be employed.

Protective Cover. Approximately 7.6 centimeters (3 inches) of crushed gravel serve as the cover of the exterior dike walls. This coarse material is inherently resistant to the effect of wind because of its large grain size. Total annual precipitation is low (16 centimeters [6.3 inches]) and a significant storm event (e.g., a 25-year, 24-hour storm) could result in about 5.3 centimeters (2.1 inches) of precipitation in a

24-hour period. The absorbent capacity of the soil exceeds this precipitation rate; therefore, the impact of wind and precipitation run-on to the exterior dike walls will be minimal.

C.5.5 Piping Systems

Aqueous waste from the 242-A Evaporator is transferred to the LERF using a pump located in the 242-A Evaporator and approximately 1,500 meters (5,000 feet) of pipe, consisting of a 7.6-centimeter (3-inch) carrier pipe within a 15.2-centimeter (6-inch) outer containment pipeline. Flow through the pump is controlled ~~through~~ by a valve, at flow rates from 150 to 300 liters (40 to 80 gallons) per minute. The pipeline exits the 242-A Evaporator below grade and remains below grade at a minimum 1.2-meter (4-feet) depth for freeze protection, until the pipeline emerges at the LERF catch basin, at the corner of each basin. All piping at the catch basin that is less than 1.2 meters (4 feet) below grade is wrapped with electric heat tracing tape and insulated for protection from freezing.

The transfer line from the 242-A Evaporator is centrifugally cast, fiberglass-reinforced epoxy thermoset resin pressure pipe fabricated to meet the requirements of ASME D2997, *Standard Specification for Centrifugally Cast Reinforced Thermosetting Resin Pipe* (ASME 1984). The 7.6-centimeter (3-inch) carrier piping is centered and supported within 15.2-centimeter (6-inch) containment piping. Pipe supports are fabricated of the same material as the pipe, and meet the strength requirements of ANSI B31.3, *Process Piping Guide* (ANSI 1987) for dead weight, thermal, and seismic loads. A catch basin is provided at the northwest corner of each basin where piping extends from the basin to allow for basin-to-basin and basin-to-200 Area ETF liquid transfers. Drawing H-2-88766, Sheets 1 through 4, provide schematic diagrams of the piping system at LERF. Drawing H-2-79604 provides details of the piping from the 242-A Evaporator to LERF.

C.5.5.1 Secondary Containment System for Piping

The 15.2-centimeter (6-inch) containment piping encases the 7.6-centimeter (3-inch) carrier pipe from the 242-A Evaporator to the LERF. All of the piping and fittings that are not directly over a catch basin or a basin liner are of this pipe-within-a-pipe construction. A catch basin is provided at the northwest corner of each basin where the inlet pipes, leachate risers, and transfer pipe risers emerge from the basin. The catch basin consists of a 20-centimeter (8-inch)-thick concrete pad at the top of the dike. The perimeter of the catch basin has a 20-centimeter (8-inch)-high curb, and the concrete is coated with a chemical resistant epoxy sealant. The concrete pad is sloped so that any leaks or spills from the piping or pipe connections will drain into the basin. The catch basin provides an access point for inspecting, servicing, and operating various systems such as transfer valving, leachate level instrumentation and leachate pump. Drawing H-2-79593 provides a schematic diagram of the catch basins.

C.5.5.2 Leak Detection System

During operation, the 242-A Evaporator receives dilute tank waste directly from the Tank Farms, treats waste by evaporation, and returns the concentrated waste to Tank Farms. The process condensate ~~which~~ that is generated is transferred to LERF. Single-point electronic leak detection elements are installed along the transfer line at 305-meter (1,000-feet) intervals. The leak detection elements are located in the bottom of specially designed test risers. Each sensor element employs a conductivity sensor, which is connected to a cable leading back to the 242-A Evaporator ~~e~~Control ~~r~~Room. If a leak develops in the carrier pipe, fluid will travel down the exterior surface of the carrier pipe or the interior of the containment pipe. As moisture contacts a sensor unit, an alarm sounds in the 200 Area ETF ~~e~~Control ~~r~~Room, which is monitored continuously when the 242-A ~~e~~Evaporator is transferring liquids to LERF. If the alarm sounds, 200 Area ETF Operations staff troubleshoots the alarm and, upon verification of a leak, requests that the pump located in the 242-A Evaporator be shut down to stop the flow of process condensate through the transfer line. The 242-A Evaporator has limited surge capacity, and its operation is closely tied to supporting Tank Farm operations. The flow of process condensate to LERF is not stopped automatically by indication of a possible leak in the primary transfer line. A low-volume air purge of the annulus between the carrier pipe and the containment pipe is provided to prevent condensation buildup and minimize false alarms by the leak detection elements.

The catch basins have conductivity leak detectors that alarm in the 200 Area ETF ~~c~~Control ~~r~~Room. Leak detector alarms are monitored in the 200 Area ~~c~~Control ~~r~~Room continuously during aqueous waste transfers and at least daily when no transfers are occurring. Leaks into the catch basins drain back to the basin through a 5.1~~-~~-centimeter (2-inch) drain on the floor of the catch basin.

C.5.5.3 Certification

Although an integrity assessment is not required for piping associated with surface impoundments, an assessment of the transfer liner was performed, including a hydrostatic leak/pressure test at 10.5 kilograms per square centimeter (150 pounds per square inch) gauge. A statement by an independent, qualified, registered professional engineer attesting to the integrity of the piping system is included in *Integrity Assessment Report for the 242-A Evaporator/LERF Waste Transfer Piping, Project W105* (WHC-SD-WM-ER-112, 1993), along with the results of the leak/pressure test.

C.5.6 Double Liner and Leak Detection, Collection, and Removal System

The double-liner system for LERF is discussed in Section C.5.2. The leachate detection, collection, and removal system (Figures C.16~~18~~ and ~~Figure~~ C.17~~19~~) was designed and constructed to remove leachate that might permeate the primary liner. System components for each basin include:

- 30.5-centimeter (12-inch) layer of drainage gravel below the primary liner at the bottom of the basin
- Geonet below the primary liner on the sidewalls to direct leachate to the gravel layer
- 3~~.0 meter~~ by 1.8~~-meter~~ by 0.30-meter (10 by 6 by 1-feet)-deep leachate collection sump consisting of a 25 millimeter (1-inch) high-density polyethylene flat stock, geotextile to trap large particles in the leachate, and 60-mil (1.5-millimeter [0.06 inch]) high-density polyethylene rub sheet set on the secondary liner
- 25.4-centimeter (10-inch) and 10.2-centimeter (4-inch) perforated leachate high-density polyethylene riser pipes from the leachate collection sump to the catch basin northwest of the basin
- Leachate collection sump level instrumentation installed in the 10.2-centimeter (4-inch) riser pipe
- Level sensors, submersible leachate pump, and 3.8-centimeter (1.5-inch) fiberglass-reinforced epoxy thermoset resin pressure piping installed in the 25.4-centimeter (10-inch) riser pipe
- Piping at the catch basin to route the leachate through 3.8-centimeter (1.5-inch) high-density polyethylene pipe back to the basins

The bottom of the basins has a two percent slope to allow gravity flow of leachate to the leachate collection sump. This exceeds the minimum of 1 percent slope required by WAC 173-303-650(j) for new surface impoundments. Material specifications for the leachate collection system are given in Section C.5.2.1.1.

Calculations demonstrate that fluid from a small hole (2 millimeter [0.08 inch]) (*Requirements for Hazardous Waste Landfill Design, Construction, and Closure*, EPA/625/4-89/022, 1989, p. 122) at the furthest end of the basin, under a low head situation, would travel to the sump in less than 24 hours (*Calculations for Liquid Effluent Retention Facility Part B Permit Application*, HNF-SD-LEF-TI-005, 1997). Additional calculations indicate the capacity of the pump to remove leachate is sufficient to allow time to readily identify a leak and activate emergency procedures (HNF-SD-LEF-TI-005, 1997).

The fluid level in each leachate sump is required to be maintained below 33 centimeters (13 inches) to prevent significant liquid backup into the drainage layer. The leachate pump is activated when the liquid level in the sump reaches about 28 centimeters (11 inches), and is shut off when the sump liquid level reaches about 18 centimeters (7 inches). This operation may be done either manually or automatically. Liquid level control is accomplished with conductivity probes that trigger relays selected specifically for application to submersible pumps and leachate fluids. A flow meter/totalizer on the leachate return pipe measures fluid volumes pumped and pumping rate from the leachate collection sumps, and indicates

volume and flow rate on local readouts. In addition, a timer on the leachate pump tracks the cumulative pump operating time. Other instrumentation provided is real-time continuous level monitoring with readout at the catch basin. Leachate levels are monitored at least weekly. A sampling port is provided in the leachate piping system at the catch basin. The leak rate through the primary liner can be calculated using two methods: 1) measured as the leachate flow meter/totalizer readings (flow meters/totalizers are located on the outflow line from the collection sumps in the bottom of the LERF basins), and 2) calculated using the pump operating time readings multiplied by the pump flow rate (the pump runs at a constant flow rate). Calculations using either method are sufficient for compliance. For more information on inspections, refer to Addendum I.

The stainless steel leachate pump delivers 19 liters (5 gallons) per minute~~(19 liters per minute)~~. The leachate pump returns draw liquid from the sump via 3.8-centimeter (1.5-inch) pipe and discharges into the basin through 3.8-centimeter (1.5-inch) high-density polyethylene pipe.

C.5.7 Construction Quality Assurance

The construction quality assurance plan and complete report of construction quality assurance inspection and testing results are provided in *242-A Evaporator Interim Retention Basin Construction Quality Assurance Plan* (CQAPLN2.QS.1149, Rev. 4, KEH 1991). A general description of construction quality assurance procedures is outlined in the following paragraphs.

For excavation of the basins and construction of the dikes, regular inspections were conducted to ensure compliance with procedures and drawings, and compaction tests were performed on the dike soils.

For the soil/bentonite layer, test fills were first conducted in accordance with EPA guidance to demonstrate compaction procedures and to confirm compaction and permeability requirements can be met. The ratio of bentonite to soil and moisture content was monitored; lifts did not exceed 15 centimeters (6 inches) before compaction, and specific compaction procedures were followed. Laboratory and field tests of soil properties were performed for each lift and for the completed test fill. The same suite of tests was conducted for each lift during the laying of the soil/bentonite admixture in the basins.

Geotextiles and geomembranes were laid in accordance with detailed procedures and quality assurance programs provided by the manufacturers and installers. These included destructive and nondestructive tests on the geomembrane seams, and documentation of field test results and repairs.

C.5.8 Proposed Action Leakage Rate and Response Action Plan

An action leakage rate limit is established where action must be taken due to excessive leakage from the primary liner. The action leak rate is based on the maximum design flow rate the leak detection system can remove without the fluid head on the bottom liner exceeding 30 centimeters (12 inches). The limiting factor in the leachate removal rate is the hydraulic conductivity of the drainage gravel. An action leakage rate (also called the rapid or large leak rate) of 20,000 liters per hectare ~~per day~~ (2,100 gallons per ~~/~~acre~~/day~~) per day was calculated for each basin (*Calculation of the Rapid or Large Leak Rate for LERF Basins in the 200 East Area*, WHC-SD-EN-TI-009, 1992~~b~~).

When it is determined that the action leakage rate has been exceeded, the response action plan will follow the actions in WAC 173-303-650(11)(b) and (c), which includes notification of Ecology in writing within 7 days, assessing possible causes of the leak, and determining whether waste receipt should be curtailed and/or the basin emptied.

C.5.9 Dike Structural Integrity Engineering Certification

The structural integrity of the dikes was certified attesting to the structural integrity of the dikes, signed by a qualified, registered professional engineer.

C.5.10 Management of Ignitable, Reactive, or Incompatible Wastes

Although ignitable or reactive aqueous waste might be received in small quantities at LERF, such aqueous waste is mixed with dilute solutions in the basins, removing the ignitable or reactive characteristics. For compatibility requirements with the LERF liner, refer to Addendum B, Waste Analysis Plan.

C.6 Air Emissions Control

This section addresses the 200 Area ETF requirements of Air Emission Standards for Process Vents, under 40 CFR 264, Subpart AA (WAC 173-303-690 incorporated by reference) and Subpart CC. The requirements of 40 CFR 264, Subpart BB (WAC 173-303-691) is not applicable because aqueous waste with 10 percent or greater organic concentration would not be acceptable for processing at the ETF.

C.6.1 Applicability of Subpart AA Standards

The ~~200 Area ETF e~~Evaporator Vapor Body Vessel and thin film dryer perform operations that specifically require evaluation for applicability of WAC 173-303-690. Aqueous waste in these units routinely contains greater than 10- parts per million concentrations of organic compounds and are, therefore, subject to air emission requirements under WAC 173-303-690. Organic emissions from all affected process vents on the Hanford Facility must be less than 1.4 kilograms (3 pounds) per hour and 2.8 mega grams (3.1 tons) per year, or control devices must be installed to reduce organic emissions by 95 percent.

The vessel off gas system provides a process vent system. This system provides a slight vacuum on the 200 Area ETF process vessels and tanks (~~refer to~~see Section C.2.5.2). Two vessel vent header pipes combine and enter the vessel off gas system filter unit consisting of a demister, electric heater, prefilter, high-efficiency particulate air filters, activated carbon absorber, and two exhaust fans (one fan in service while the other is backup). The vessel off gas system filter unit is located in the high-efficiency particulate air filter room west of the 2025-E ~~p~~Process ~~a~~Area. The vessel off gas system exhaust discharges into the larger building ventilation system, with the exhaust fans and stack located outside and immediately west of the ETF. The exhaust stack discharge point is 15.5 meters (51 feet) above ground level.

The annual average flow rate for the 200 Area ETF stack (which is the combined vessel off gas and building exhaust flow rates) is 1600 cubic meters (56,000 cubic feet) per minute with a total annual flow of approximately 8.4 E+08 cubic meters (2.9E+10 cubic feet). During waste processing, the airflow through just the vessel off gas system is about 23 standard cubic meters (800 standard cubic feet) per minute.

Organic emissions occur during waste processing, which occurs less than 310 days each year (i.e., 85 percent operating efficiency). This operating efficiency represents the maximum annual operating time for the ETF, as shutdowns are required during the year for planned maintenance outages and for reconfiguring the 200 Area ETF to accommodate different aqueous waste.

C.6.2 Process Vents - Demonstrating Compliance

This section outlines how the 200 Area ETF complies with the requirements and includes a discussion of the basis for meeting the organic emissions limits, calculations demonstrating compliance, and conditions for reevaluation.

C.6.2.1 Basis for Meeting Limits/Reductions

The 242-A Evaporator and the 200 Area ETF are currently the only operating TSD units that contribute to the Hanford Facility volatile organic emissions under 40 CFR 264, Subpart AA. The combined release rate is currently well below the threshold of 1.4 kilograms (3 pounds) per hour and~~or~~ 2.8 mega grams ~~2,800 kilograms~~ (3.1 tons) per year of volatile organic compounds. As a result, the 200 Area ETF meets these standards without the use of air pollution control devices.

The amount of organic emissions could change as waste streams are changed, or TSD units are brought online or are deactivated. The organic air emissions summation will be re-evaluated periodically as condition warrants. Operations of the TSD units operating under 40 CFR 264, Subpart AA, will be controlled to maintain Hanford Facility emissions below the threshold limits or pollution control device(s) will be added, as necessary, to achieve the reduction standards specified under 40 CFR 264, Subpart AA.

C.6.2.2 Demonstrating Compliance

Calculations to determine organic emissions are performed using the following assumptions:

- Maximum flow rate from LERF to 200 Area ETF is 568 liters (150 gallons) per minute.
- Emissions of organics from tanks and vessels upstream of the UV/OX process are determined from flow and transfer rates given in *Clean Air Act Requirements*, WAC 173-400, and *As-built Documentation, Project C-018H, 242-A Evaporator/PUREX Plant Process Condensate Treatment Facility* (Adtechs 1995).
- UV/OX reaction rate constants and residence times are used to determine the amount of organics, which are destroyed in the UV/OX process. These constants are given in *200 Area Effluent Treatment Facility Delisting Petition* (DOE/RL-92-72 19932).
- All organic compounds that are not destroyed in the UV/OX process are assumed to be emitted from the tanks and vessels into the vessel off gas system.
- No credit for removal of organic compounds in the vessel off gas system carbon absorber unit is taken. The activated carbon absorbers are used if required to reduce organic emissions.

The calculation to determine organic emissions consists of the following steps:

1. Determine the quantity of organics emitted from the tanks or vessels upstream of the UV/OX process, using transfer rate values
2. Determine the concentration of organics in the waste after the UV/OX process using UV/OX reaction rates and residence times. If the 200 Area ETF is configured such that the UV/OX process is not used, a residence time of zero is used in the calculations (i.e., none of the organics are destroyed)
3. Assuming all the remaining organics are emitted, determine the rate which the organics are emitted using the feed flow rate and the concentrations of organics after the UV/OX process
4. The amount of organics emitted from the vessel off gas system is the sum of the amount calculated in steps 1 and 3.

The organic emission rates and quantity of organics emitted during processing are determined using these calculations and are included in the Hanford Facility Operating Record, LERF and 200 Area ETF file.

C.6.2.3 Reevaluating Compliance with Subpart AA Standards

Calculations to determine compliance with Subpart AA will be reviewed when any of the following conditions occur at the 200 Area ETF:

- Changes in the maximum feed rate to the 200 Area ETF (i.e., greater than the 568 liters (150 gallons) per minute flow rate)
- Changes in the configuration or operation of the 200 Area ETF that would modify the assumptions given in Section C.6.2.2 (e.g., taking credit for the carbon absorbers as a control device)
- Annual operating time exceeds 310 days.

C.6.3 Applicability of Subpart CC Standards

The air emission standards of 40 CFR 264, Subpart CC apply to tank, surface impoundment, and container storage units that manage wastes with average volatile organic concentrations equal to or exceeding 500 parts per million by weight, based on the hazardous waste composition at the point of

origination (61 FR 59972). However, TSD units that are used solely for management of mixed waste are exempt. Mixed waste is managed at the LERF and 200 Area ETF and dangerous waste could be treated and stored at these TSD units.

TSD owner/operators are not required to determine the concentration of volatile organic compounds in a hazardous waste if the wastes are placed in waste management units that employ air emission controls that comply with the Subpart CC standards. Therefore, the approach to Subpart CC compliance at the LERF and 200 Area ETF is to demonstrate that the LERF and 200 Area ETF meet the Subpart CC control standards (40 CFR 264.1084 – 40 CFR 264.1086).

C.6.3.1 Demonstrating Compliance with Subpart CC for Tanks

Since the 200 Area ETF tanks already have process vents regulated under 40 CFR 264, Subpart AA (WAC 173-303-690), they are exempt from Subpart CC [40 CFR 264.1080(b)(8)].

C.6.3.2 Demonstrating Compliance with Subpart CC for Containers

Container Level 1 and Level 2 standards are met at the 200 Area ETF by managing all dangerous and/or mixed wastes in U.S. Department of Transportation containers [40 CFR 264.1086(f)]. Level 1 containers are those that store more than 0.1 cubic meters (3.5 cubic feet) and less than or equal to 0.46 cubic meters (16 cubic feet). Level 2 containers are used to store more than 0.46 cubic meters (16 cubic feet) of waste, which are in 'light material service'. Light material service is defined where a waste in the container has one or more organic constituents with a vapor pressure greater than 0.3 kilograms per square meter ~~kilopascals~~(0.04 pounds per square inch) at 20°-C (68°F), and the total concentration of such constituents is greater than or equal to 20- percent by weight.

The monitoring requirements for Level 1 and Level 2 containers must include a visual inspection when the container is received at the 200 Area ETF, ~~and~~ when ~~the~~ waste is initially placed in the container. ~~Additionally~~, and at least once every 12 months when stored onsite for 1 year or more~~, these containers must be inspected~~.

If compliant containers are not used at the 200 Area ETF, alternate container management practices are used that comply with the Level 1 standards. Specifically, the Level 1 standards allow for a "container equipped with a cover and closure devices that form a continuous barrier over the container openings such that when the cover and closure devices are secured in the closed position there are no visible holes, gaps, or other open spaces into the interior of the container. The cover may be a separate cover installed on the container...or may be an integral part of the container structural design…" [40 CFR 264.1086(c)(1)(ii)]. An organic-vapor-suppressing barrier, such as foam, may also be used [40 CFR 264.1086(c)(1)(iii)]. Section C.3 provides detail on container management practices at the 200 Area ETF.

Container Level 3 standards apply when a container is used for the "treatment of a hazardous waste by a waste stabilization process" [40 CFR 264.1086(2)]. Because treatment in containers using the stabilization process is not provided at the 200 Area ETF, these standards do not apply.

C.6.3.3 Demonstrating Compliance with Subpart CC for Surface Impoundments

The Subpart CC emission standards are met at LERF using a floating membrane cover that is constructed of very-low-density polyethylene that forms a continuous barrier over the entire surface area [40 CFR 264.1085(c)]. This membrane has both organic permeability properties equivalent to a high-density polyethylene cover and chemical/physical properties that maintain the material integrity for the intended service life of the material. The additional requirements for the floating cover at the LERF have been met (Section C.5.2.4).

C.7 Engineering Drawings

C.7.1 Liquid Effluent Retention Facility

Drawings of the containment systems at the LERF are summarized in Table C.1. Because the failure of these containment systems at LERF could lead to the release of dangerous waste into the environment,

modifications that affect these containment systems will be submitted to the Washington State Department of Ecology, as a Class 1, 2, or 3 Permit modification, as required by WAC 173-303-830.

Table C.1. Liquid Effluent Retention Facility Containment System

LERF System	Drawing Number	Drawing Title
Bottom Liner	H-2-79590, Sheet 1	Civil Plan, Sections ~~and~~ & Det~~ails~~; Cell Basin Bottom Liner
Top Liner	H-2-79591, Sheet 1	Civil Plan, Sections ~~and~~& Det~~ails~~; Cell Basin ~~Bottom~~ Top Liner
Catch Basin	H-2-79593, Sheet 1, 3-5	Civil Plan, Sections ~~and~~ & Det~~ails~~; Catch Basin

The drawings identified in Table C.2 illustrate the piping and instrumentation configuration within LERF, and of the transfer piping systems between the LERF and the 242-A Evaporator. These drawings are provided for general information, and to demonstrate the adequacy of the design of the LERF as a surface impoundment.

Table C.2. Liquid Effluent Retention Facility Piping and Instrumentation

LERF System	Drawing Number	Drawing Title
Transfer Piping to 242-A Evaporator	H-2-79604, Sheet 1	Piping Plot ~~and~~& Key Plans; 242-A Evap~~orator~~ Cond~~ensate~~ Stream
LERF Piping and Instrumentation	H-2-88766, Sheet 1	P&ID; LERF Basin ~~and~~& ETF Influent Evaporator
	H-2-88766, Sheet 2	P&ID; LERF Basin ~~and~~& ETF Influent
	H-2-88766, Sheet 3	P&ID; LERF Basin ~~and~~& ETF Influent
	H-2-88766, Sheet 4	P&ID; LERF Basin ~~and~~& ETF Influent
Legend	H-2-89351, Sheet 1	Piping & Instrumentation Diagram - Legend

C.7.2 200 Area Effluent Treatment Facility

Drawings of the secondary containment systems for the 200 Area ETF containers, and tanks and process units, and for the Load-In Station ~~T~~tanks are summarized in Table C.3. Because the failure of the secondary containment systems could lead to the release of dangerous waste into the environment, modifications, which affect the secondary containment systems, will be submitted to the Washington State Department of Ecology, as a Class 1, 2, or 3 Permit modification, as required by WAC 173-303-830.

Table C.3. ~~Effluent Treatment Facility~~ Building 2025-E and Load-In Station Secondary Containment Systems

200 Area ETF Process Unit	Drawing Number	Drawing Title
Surge Tank, Process/2025-E Container Storage Areas and Trenches - Foundation and Containment	H-2-89063, Sheet 1	~~Architectural/s~~Structural —Foundation ~~and~~ & Grade Beam Plan
Sump Tank Containment	H-2-89065, Sheet 1	~~Architectural/s~~Structural —Foundation, Sections ~~and~~& Details
Verification Tank Foundation and Containment	H-2-89068, Sheet 1	~~Architectural/s~~Structural —Verification Tank Foundations
Load-In Station ~~Facility~~ Foundation and Containment	H-2-817970, Sheet 1	Structural —ETF Truck Load-in Facility Plans and Sections
Load-In Station ~~Facility~~ Foundation and Containment	H-2-817970, Sheet 2	Structural —ETF Truck Load-in Facility Plans and Sections ~~and Details~~

The drawings identified in Table C.4 provide an illustration of the piping and instrumentation configuration for the major process units and tanks at the 200 Area ETF, and the Load-In Station ~~T~~tanks. Drawings of the transfer piping systems between the LERF and 200 Area ETF, and between the Load-In Station and the 200 Area ETF also are presented in this table. These drawings are provided for general information, and to demonstrate the adequacy of the design of the tank systems.

Table C.4. Major Process Units and Tanks at Building 2025-E ~~the Effluent Treatment Facility~~ and Load-In Station

200 Area ETF Process Unit	Drawing Number	Drawing Title
Load-In ~~Facility~~Station	H-2-817974, Sheet 1	P&ID – ETF Truck Load-In Facility
Load-In ~~Facility~~Station	H-2-817974, Sheet 2	P&ID – ETF Truck Load-In Facility
Surge Tank	H-2-89337, Sheet 1	P&ID – Surge Tank System
UV/Oxidation	H-2-88976, Sheet 1	P&ID – UV Oxidizer Part 1
UV/Oxidation	H-2-89342, Sheet 1	P&ID – UV Oxidizer Part 2
Reverse Osmosis	H-2-88980, Sheet 1	P&ID – 1st RO Stage
Reverse Osmosis	H-2-88982, Sheet 1	P&ID – 2nd RO Stage
IX/Polishers	H-2-88983, Sheet 1	P&ID – Polisher
Verification Tanks	H-2-88985, Sheet 1	P&ID – Verification Tank System
~~ETF~~ Evaporator Vapor Body Vessel	H-2-89335, Sheet 1	P&ID – Evaporator
Thin Film Dryer	H-2-88989, Sheet 1	P&ID – Thin Film Dryer
Transfer Piping from LERF to ~~ETF~~building 2025-E	H-2-88768, Sheet 1	Piping Plan/Profile 4"– 60M-002-M17 and 3"-60M-001-M17
Transfer Piping from Load-In ~~Facility~~ Station to building 2025-E~~ETF~~	H-2-817969, Sheet 1	Civil – ETF Truck Load-In Facility Site Plan

1 **Table C.5. 200 Area Effluent Treatment Facility Tank Systems Information**

Tank Description	Material of Construction[1]	Unit of Measure	Maximum Tank Capacity[2] liters/gallon	Inner diameter meters/feet	Height meters/feet	Shell Thickness[3] centimeters/ inch	Corrosion Protection[1]
Load-~~i~~In Station tanks 2025ED-59A-TK-109~~/~~ 2025ED-59A-TK-117 ~~(2)~~	304 SS	Metric	34,350	3.6	4.7	0.64	Type 304 SS
		Standard	9,100	12	15.4	1/4	
Load-~~i~~In Station tank 2025ED-59A-TK-1	FRP	Metric	26,000	3.0	3.8	0.48 (dome) 0.63 (walls & bottom)	FRP
		Standard	6,900	10	11.5	3/16 1/4	
Surge tank 2025E-60A-TK-1	304 SS	Metric	462,000	7.9	9.2	0.48	Type 304 SS
		Standard	122,000	26	30	3/16	
pH adjustment tank 2025E-60C-TK-1	304 SS	Metric	16,700	3.0	2.5	0.64	Type 304 SS
		Standard	4,400	10	8	1/4	
First RO feed tank 2025E-60F-TK-1	304 SS	Metric	20,600	3.0	3.2	0.64	Type 304 SS
		Standard	5,400	10	10.5	1/4	
Second RO feed tank 2025E-60F-TK-2	304 SS	Metric	9,000	~~Nonround tank~~ 3.0 ~~m~~ x 1.5 ~~m~~	1.5	0.48 w/rib stiffeners	Type 304 SS
		Standard	2,400	10 x 5	5	3/16	
Effluent pH adjustment tank 2025E-60C-TK-2	304 SS	Metric	14,400	2.4	3.6	0.64	Type 304 SS
		Standard	3,800	8	12	1/4	
Verification tanks ~~(3)~~ 2025E-60H-TK-1A 2025E-60H-TK-1B 2025E-60H-TK-1C	Carbon steel with epoxy lining	Metric	3,025,739 ~~3,000,000~~	18.3	11.4	0.79	epoxy coating
		Standard	799,316	60	37	5/16	
Secondary waste receiving tanks ~~(2)~~ 2025E-60I-TK-1A 2025E-60I-TK-1B	304 SS	Metric	73,800	4.3	5.7	0.64	Type 304 SS
		Standard	19,500	14	18.7	1/4	
Concentrate tanks ~~(2)~~ 2025E-60J-TK-1A 2025E-60J-TK-1B	316L SS	Metric	24,900	3.0	3.8	0.64	Type 316 SS
		Standard	6580	10	11.5	1/4	
	Alloy 625	Metric	20,000	2.4	6.8	variable	All

[1] Type 304 SS, 304L, 316 SS and alloy 625 provide corrosion protection.
[2] The maximum tank capacity is identified in CHPRC-01900, Revision 2
[3] The nominal thickness of 200 Area ETF tanks is represented.

Tank Description	Material of Construction[1]	Unit of Measure	Maximum Tank Capacity[2] liters/gallon	Inner diameter meters/feet	Height meters/feet	Shell Thickness[3] centimeters/ inch	Corrosion Protection[3]
~~ETF-e~~Evaporator ~~(~~Vapor Body~~)~~ Vessel 2025E-60I-EV-1		Standard	5300	8	22		Epoxy 625
Distillate flash tank 2025E-60I-TK-2	304 SS	Metric	950	~~Horizontal tank~~ 0.76	Length 2.2	0.7	304 SS
		Standard	250	2.5	7	9/32	
Sump ~~t~~Tank 1 2025E-20B-TK-1	304 SS	Metric	6,900	1.5 x 1.5	3.4	0.48	304 SS
		Standard	1,800	5 x 5	11	3/16	
Sump ~~t~~Tank 2 2025E-20B-TK-2	304 SS	Metric	6,700	1.5 x 1.5	3.4	0.48	304 SS
		Standard	1,770	5 x 5	11	3/16	

1 304 SS = stainless steel type 304 or 304L.
2 316L SS = stainless steel type 316L
3 FRP = Fiberglass-reinforced plastic.
4 ~~[1] The maximum operating volume of the tanks is identified.~~
5 ~~[2] The nominal thickness of ETF tanks is represented.~~
6 ~~[3] Type 304 SS, 304L, 316 SS and alloy 625 provide corrosion protection.~~

Table C.6. 200 Area Effluent Treatment Facility Additional Tank System Information

Tank Description	Liner Materials	Pressure Controls	Foundation Materials	Structural Support	Seams	Connections
Load-~~i~~In Station tanks 2025ED-59A-TK-109~~/~~ 2025ED-59A-TK-117 ~~(2)~~	None	vent to atmosphere	concrete slab	SS skirt bolted to concrete	welded	flanged
Load-~~i~~In Station tank 2025ED-59A-TK-1	None	vent to atmosphere	concrete slab	bolted to concrete	none	flanged
Surge tank 2025E-60A-TK-1	None	vacuum breaker valve/vent to VOG	reinforced concrete ring plus concrete slab	structural steel on concrete base	welded	flanged
pH adjustment tank 2025E-60C-TK-1	None	vent to VOG	concrete slab	carbon steel skirt	welded	flanged
First RO feed tank 2025E-60F-TK-1	None	vent to VOG	concrete slab	carbon steel skirt	welded	flanged
Second RO feed tank 2025E-60F-TK-2	None	vent to VOG	concrete slab	carbon steel frame	welded	flanged
Effluent pH adjustment tank 2025E-60C-TK-2	None	vent to VOG	concrete slab	carbon steel skirt	welded	flanged
Verification tanks 2025E-~~(3)~~ 60H-TK-1A 2025E-60H-TK-1B 2025E-60H-TK-1C	Epoxy	filtered vent to atmosphere	reinforced concrete ring plus concrete slab	structural steel on concrete base	welded	flanged
Secondary waste receiving tanks ~~(2)~~ 2025E-60I-TK-1A 2025E-60I-TK-1B	None	vent to VOG	concrete slab	carbon steel skirt	welded	flanged
Concentrate tanks ~~(2)~~ 2025E-60J-TK-1A 2025E-60J-TK-1B	None	vent to VOG	concrete slab	carbon steel skirt	welded	flanged
~~ETF e~~Evaporator ~~(v~~Vapor ~~b~~Body~~)~~ Vessel (2025E-60I-EV-1)	None	pressure indicator/pressure relief valve vapor vent to DFT/VOG	concrete slab	carbon steel frame	welded	flanged
Distillate flash tank 2025E-60I-TK-2	None	Pressure relief valve/vent to vent gas cooler/VOG	concrete slab	carbon steel I-beam and cradle	welded	flanged
Sump ~~t~~Tank 1 2025E-20B-TK-1	None	vent to VOG	concrete containment	reinforced concrete containment basin	welded	flanged
Sump ~~t~~Tank 2 2025E-20B-TK-2	None	vent to VOG	concrete containment	reinforced concrete containment basin	welded	flanged

DFT = distillate flash tank
VOG = vessel off gas system

Table C.7. Ancillary Equipment and Material Data

System	Ancillary Equipment	Number	Material
Load-~~i~~In Station tanks	Load-~~i~~In Station/transfer pumps (2)	2025ED-P-103A/-103B	316 SS
		2025ED-P-001A/-001B	Cast iron
	Load-~~i~~In Station filters (6)	59A-FL-001/-002/-003/ -004/-005/-006	304 SS
Surge tank	Surge tank pumps (3)	2025E-60A-P-1A/-1B/-1C	304 SS
Rough filter	Rough filter	2025E-60B-FL-1	304 SS
UV/OX	UV oxidation inlet cooler	2025E-60B-E-1	316 SS
	UV oxidizers (4)	2025E-60D-UV-1A/-1B/-2A/-2B	316 SS
pH adjustment	pH adjustment pumps (2)	2025E-60C-P-1A/-1B	304 SS
Peroxide decomposer	H_2O_2 decomposers (2)	2025E-60D-CO-1A/-1B	CS with epoxy coating
Fine filter	Fine filter	2025E-60B-FL-2	304 SS
Degasification	Degasification column inlet cooler	2025E-60E-E-1	316 SS
	Degasification column	2025E-60E-CO-1	FRP
	Degasification pumps (2)	2025E-60E-P-1A/-1B	316 SS
RO	Feed/booster pumps (6)	2025E-60F-P-1A/-1B/-2A/-2B/-3A/-3B	304 SS
	Reverse osmosis arrays (21)	2025E-60F-RO-01 through -21	Membranes: polyamide Outer piping: 304 SS
IX/Polishers	Polishers (3)	2025E-60G-IX-1A/-1B-1C	CS with epoxy coating
	Resins strainers (3)	2025E-60G-S-1A/-1B/-1C	304 SS
Effluent pH adjustment	Recirculation/transfer pumps (2)	2025E-60C-P-2A/-2B	304 SS/PVC
Verification tanks	Return pump	2025E-60H-P-1	304 SS
	Transfer pumps (2)	2025E-60H-P-2A/-2B	
Secondary waste receiving tanks	Secondary waste feed pumps (2)	2025E-60I-P-1A/-1B	304 SS
~~200 Area ETF e~~Evaporator Vapor Body Vessel system	Feed/distillate heat exchanger	2025E-60I-E-02	Tubes: 316 SS Shell: 304 SS
	Heater (reboiler)	2025E-60I-E-01	Tubes: alloy 625 Shell: 304 SS
	Recirculation pump	2025E-60I-P-02	316 SS
	Concentrate transfer pump	2025E-60I-P-04	316 SS
	Entrainment separator	2025E-60I-DE-01	Top section: 316 SS Bottom section: alloy 625
	Vapor compressor (incl. silencers)	2025E-60I-C-01	304 SS
	Silencer drain pump	2025E-60I-P-06	316 SS
	Level control tank	2025E-60I-TK-5	304 SS
	Distillate flash tank pump	2025E-60I-P-03	316 SS
Concentrate tanks	Concentrate circulation pumps (2)	2025E-60J-P-1A/-1B	316 SS
Thin film dryer	Concentrate feed pump	2025E-60J-P-2	316 SS
	Thin film dryer	2025E-60J-D-1	Interior surfaces: alloy 625 Rotor and blades: 316 SS
	Powder hopper	2025E-60J-H-1	316 SS
	Spray condenser	2025E-60J-DE-01	316 SS
	Distillate condenser	2025E-60J-CND-01	Tubes: 304 SS Shell: CS
	Dryer distillate pump	2025E-60J-P-3	316 SS
Resin dewatering	Dewatering pump	2025E-80E-P-1	

Table C.8. Concrete and ~~Masonary~~Masonry Coatings

Location	Product Name	Applied Film Thickness, Estimated	
		Mils	Inches
~~ETF~~ 2025-E Process Area, Truck Bay, and Container Storage Areas			
Floor: Topcoat	Chemproof PermaCoat 4000~~Steelcote Floor-Nu Finish~~[1]	2 coats at ~~10~~-12-16 mils	0.012-0.016 inches
~~Floor: Primer~~	~~Steelcote Monomid Hi-Build1~~	~~2.0 mils~~	
Walls to 7 feet, Doors & Jambs	Chemproof PermaCoat 4000 Vertical[1~~3~~]	2 coats at 12-16 mils	0.012-0.016 inches
Load-in Station Tank Pit			
Floor and Walls Topcoat	~~Ameron Amercoat 351~~Elasti-Liner I/II[2,3]	80 mils ~~2 coats at 8.0-12 mils~~	0.08 inches
Floor and Walls: Primer	Techni-Plus E[2]	5-7 mils	0.005-0.007 inches
Surge Tank and Verification Tank Berms			
Floors (and Walls at Surge Tank): Topcoat	~~KCC Corrosion Control~~ Elasti-Liner I[2~~4~~]	80 mils	0.08 inches
Floors (and Walls at Surge Tank): Primer	~~KCC Corrosion Control~~ Techni-Plus E3[2~~4~~]	5.0-7.0 mils	0.005-0.007 inches

[1] PermaCoat is a trademark of Chemproof Polymers, Inc.~~Floor-Nu Finish and Monomid Hi-Build are trademarks of Steelcote Manufacturing, Incorporated~~

[2] Elasti-Liner and Techni-Plus are trademarks of KCC Corrosion Control, Inc.~~PermaCoat is a trademark of Chemproof Polymers, Incorporated~~

[3] ~~Amercoat is a trademark of Ameron International, Incorporated~~

[~~4~~]Elasti-Liner I ~~and~~ or a combination of Elasti-liner I and Elasti-liner II~~Techni-Plus are trademarks of KCC Corrosion Control, Incorporated~~

Table C.9. Geomembrane Material Specifications

Property	Value
Specific gravity	0.932 to 0.950
Melt flow index	~~1.0~~ gram/10 minutes~~.~~, maximum (0.04 ounce/10 minute, maximum)
Thickness (thickness of flow marks shall not exceed 200~~%~~ percent of the nominal liner thickness)	60 mil ~~3~~±10% (1.5 ~~mm~~ millimeter [0.06 inches]- ~~3~~±- 10%)
Carbon black content	1.8 to 3%, bottom liner 2 to 3% top liner
Tensile properties (each direction)	
Tensile strength at yield	21.5 kgf/centimeter width, minimum 120 pounds/inch width, minimum
Tensile strength at break	32.2 -kgf/centimeter width, minimum 180 pounds/inch width, minimum
Elongation at yield	10%, minimum
Elongation at break	500%, minimum
Tear resistance	13.6 kgf, minimum 30 pounds, minimum
Puncture resistance	31.3 kgf, minimum 69 pounds, minimum
Low temperature/brittleness	-400-°C (-688°F), maximum
Dimensional (~~%~~percent change each direction)	~~3~~±2%, maximum
Environmental stress crack	750 hour, minimum
Water absorption	0.1% maximum and weight change
Hydrostatic resistance	316,000 kgf/meter^2 450 pounds/inch^2
Oxidation induction time (200 C/l atm. O2)	90 minutes

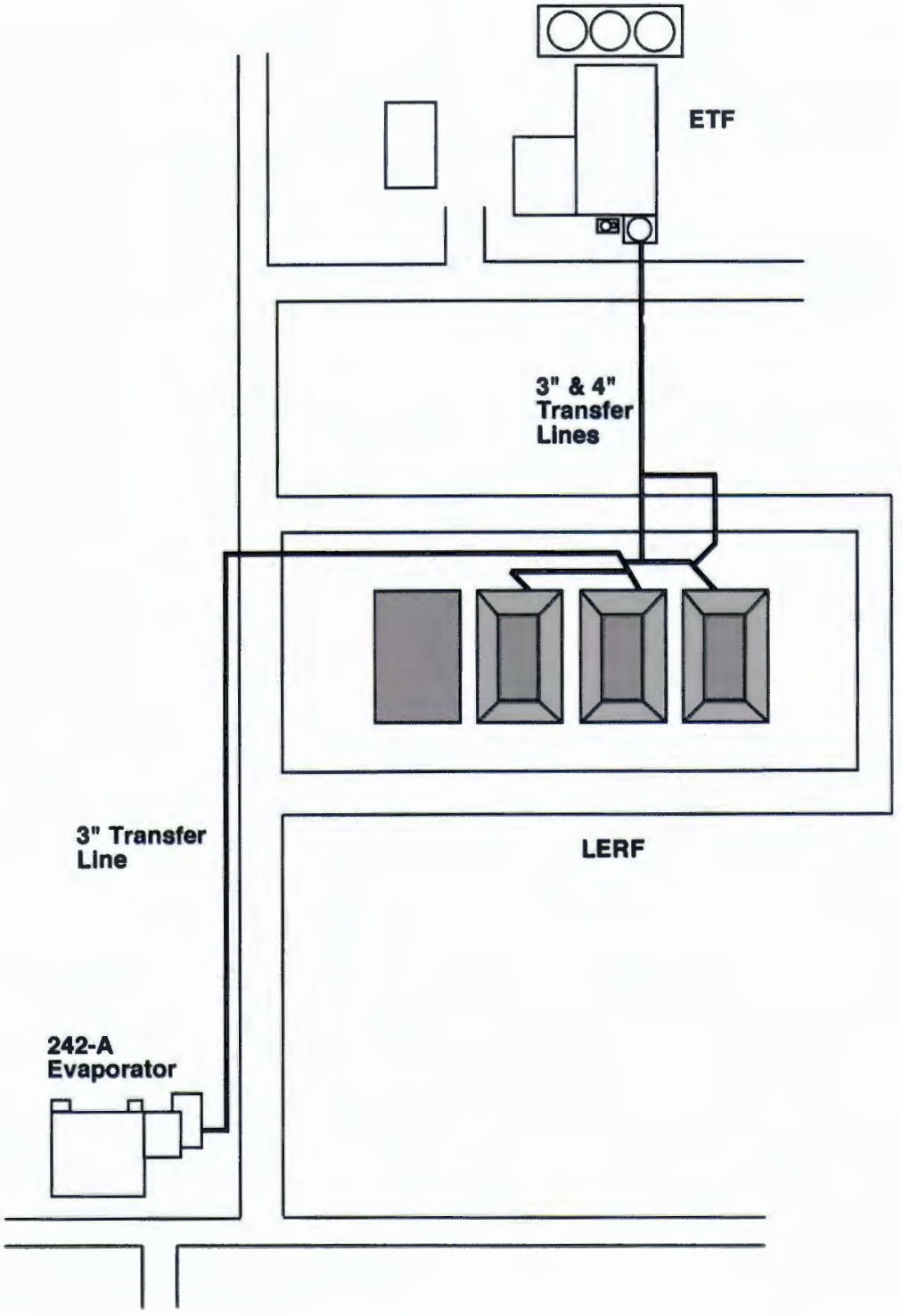
Reference: *Construction Specifications for 242-A Evaporator and PUREX Interim Retention Basins* (W-105, KEH 1990~~b~~). Format uses NSF 54 table for high-density polyethylene as a guide (NSF 1985). However, RCRA values for dimensional stability and environmental stress crack have been added.

~~% = percent~~ ~~max = maximum~~
~~g = gram~~ kgf = kilograms force
~~min = minute~~ ~~m = meters~~
~~h = hour~~ ~~mm = millimeters~~

Table C.10. Drainage Gravel Specifications

Property	Value
Sieve size	
25 millimeters (1 inches)	100 wt.% passing
19 millimeters (0.75 inches)	80 – 100 wt.% passing
9.5 millimeters (0.375 inches)	10 – 40 wt.% passing
4.75 millimeters (0.187 inches)	0 – 4 wt.% passing
Permeability	0.1 centimeters~~cm~~ (0.04 inches)/second, minimum

Reference: Sieve size is from WSDOT M41-10-88, Section 9.03.1(3)C for Grading No. 5 (WSDOT 1988). Permeability requirement is from WAC 173-303-650(2)(j) for new surface impoundments.



ETF = Effluent Treatment Facility
LERF = Liquid Effluent Retention Facility

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Figure C.1. Liquid Effluent Retention Facility Layout

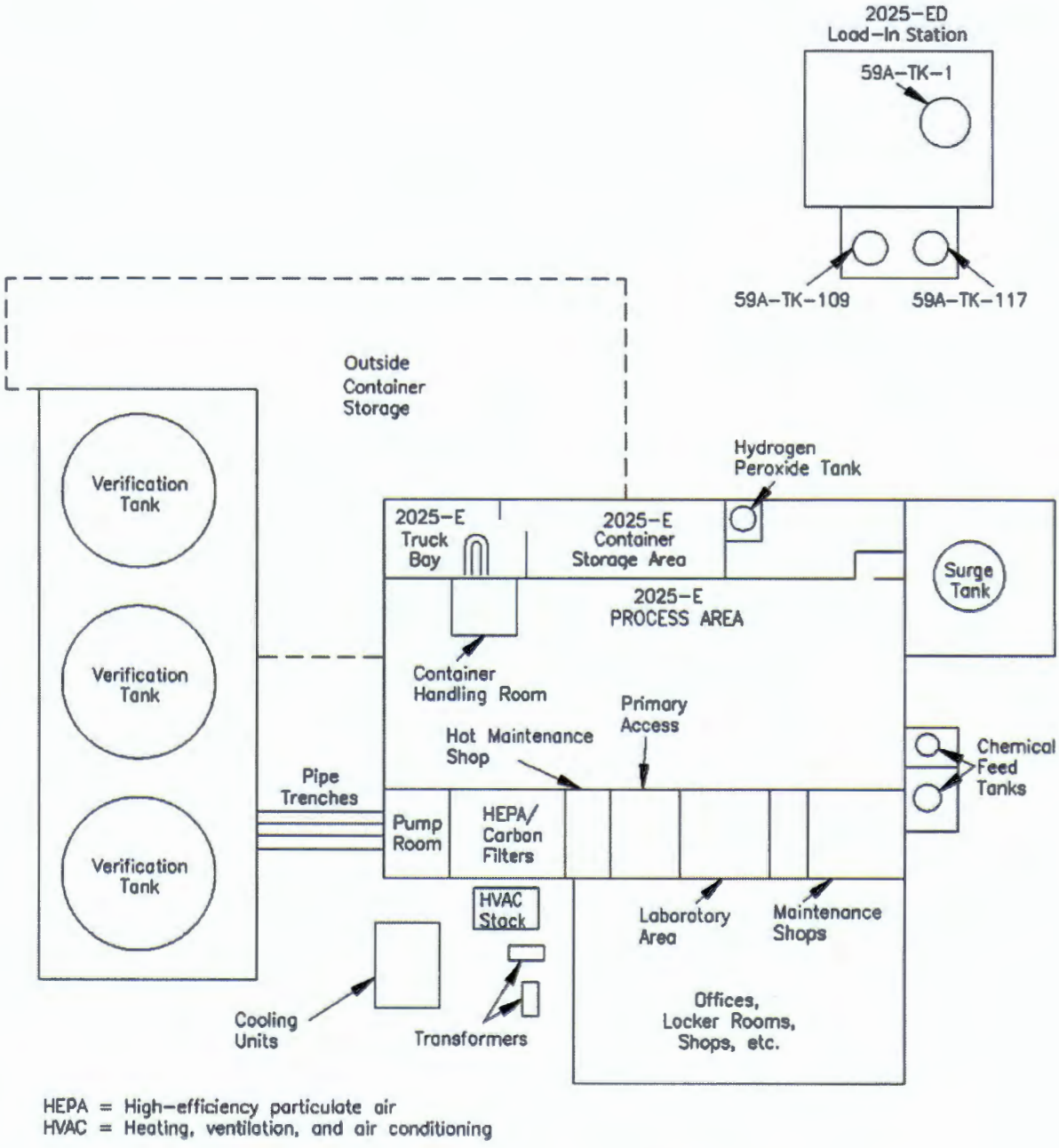


Figure C.2. Plan View of the 200 Area Effluent Treatment Facility

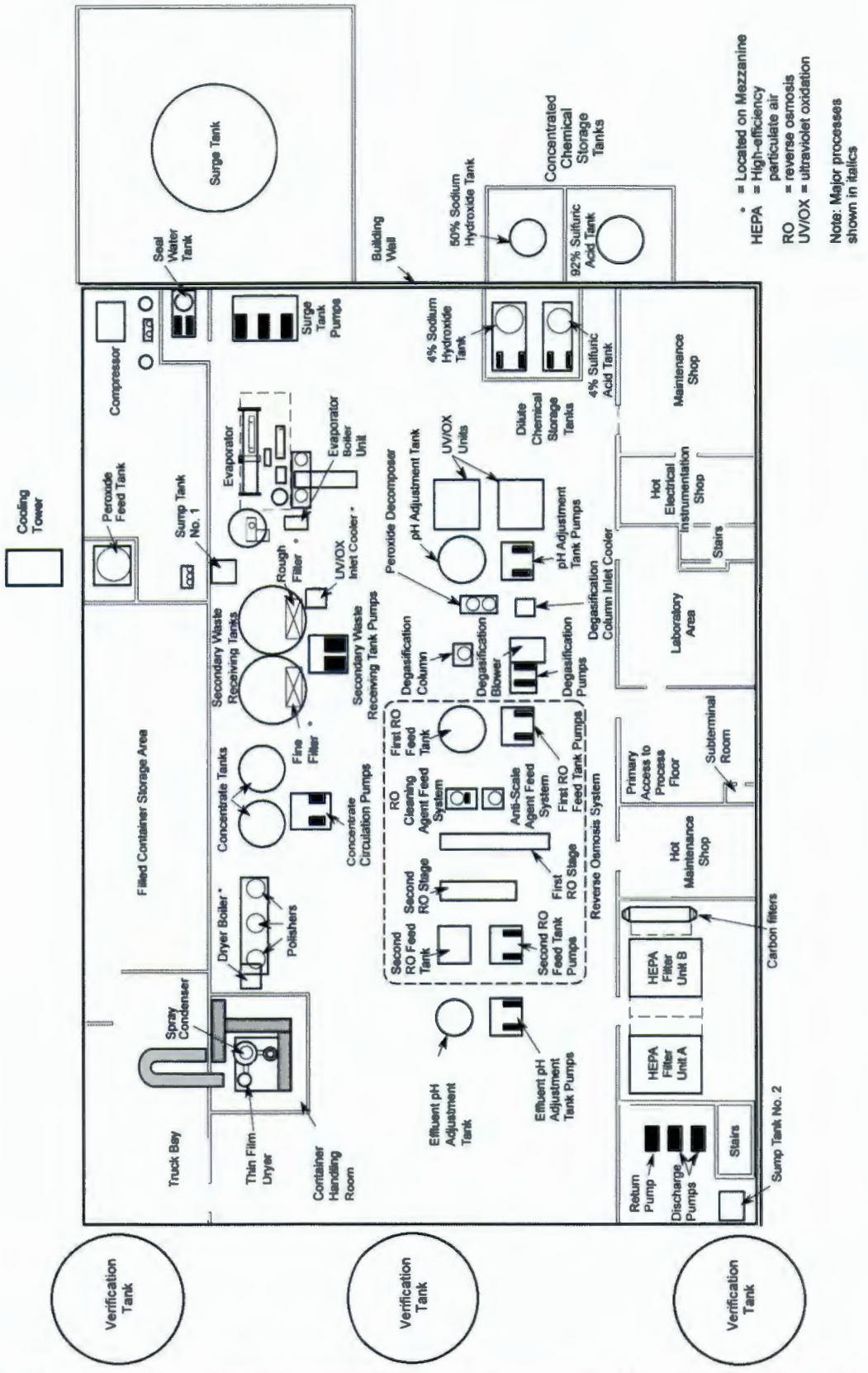


Figure C.3. ~~200 Area Effluent Treatment Facility~~Building 2025-E Ground Floor Plan ~~Layout~~

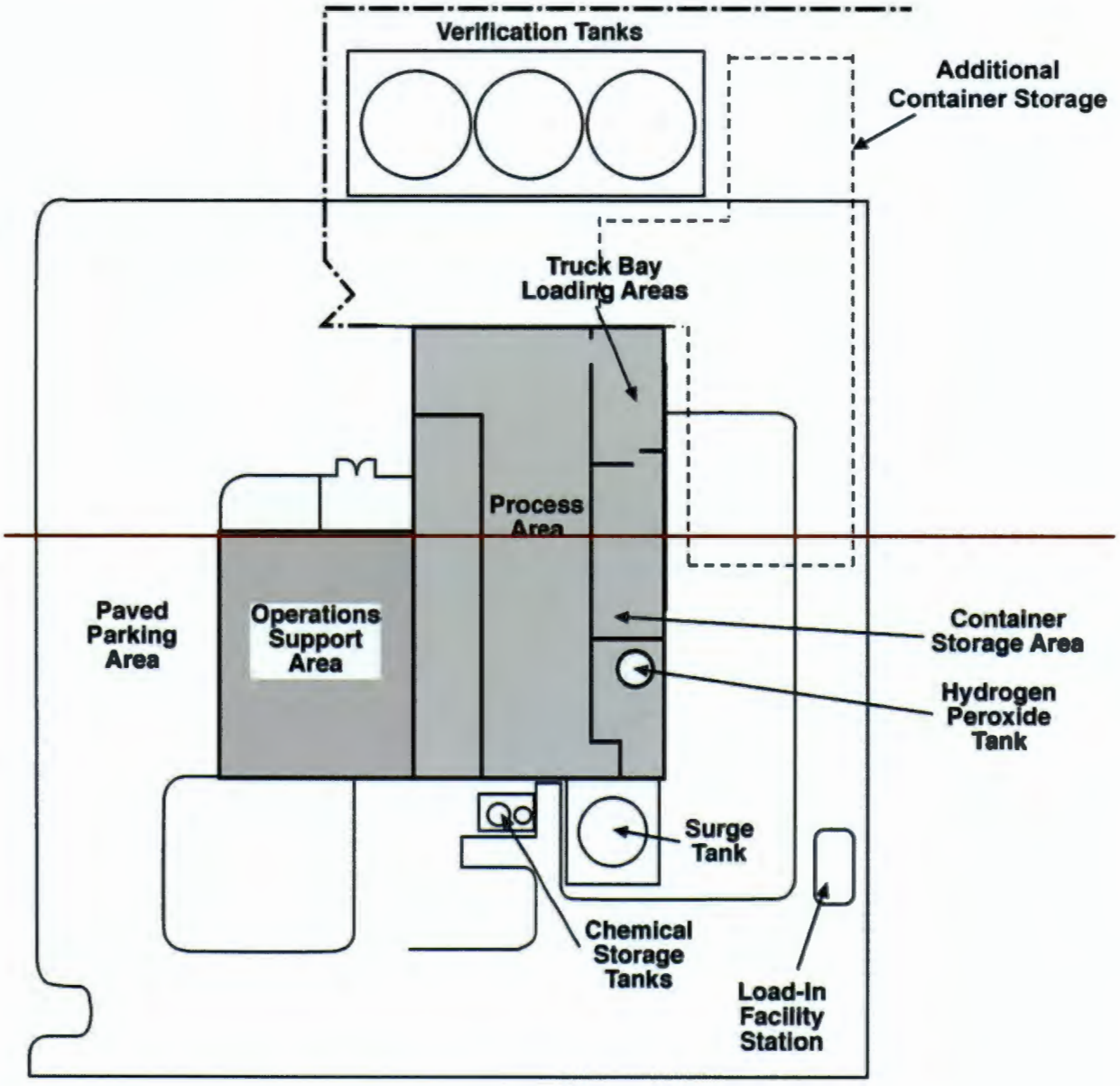


Figure C.4. 200 Area Effluent Treatment Facility

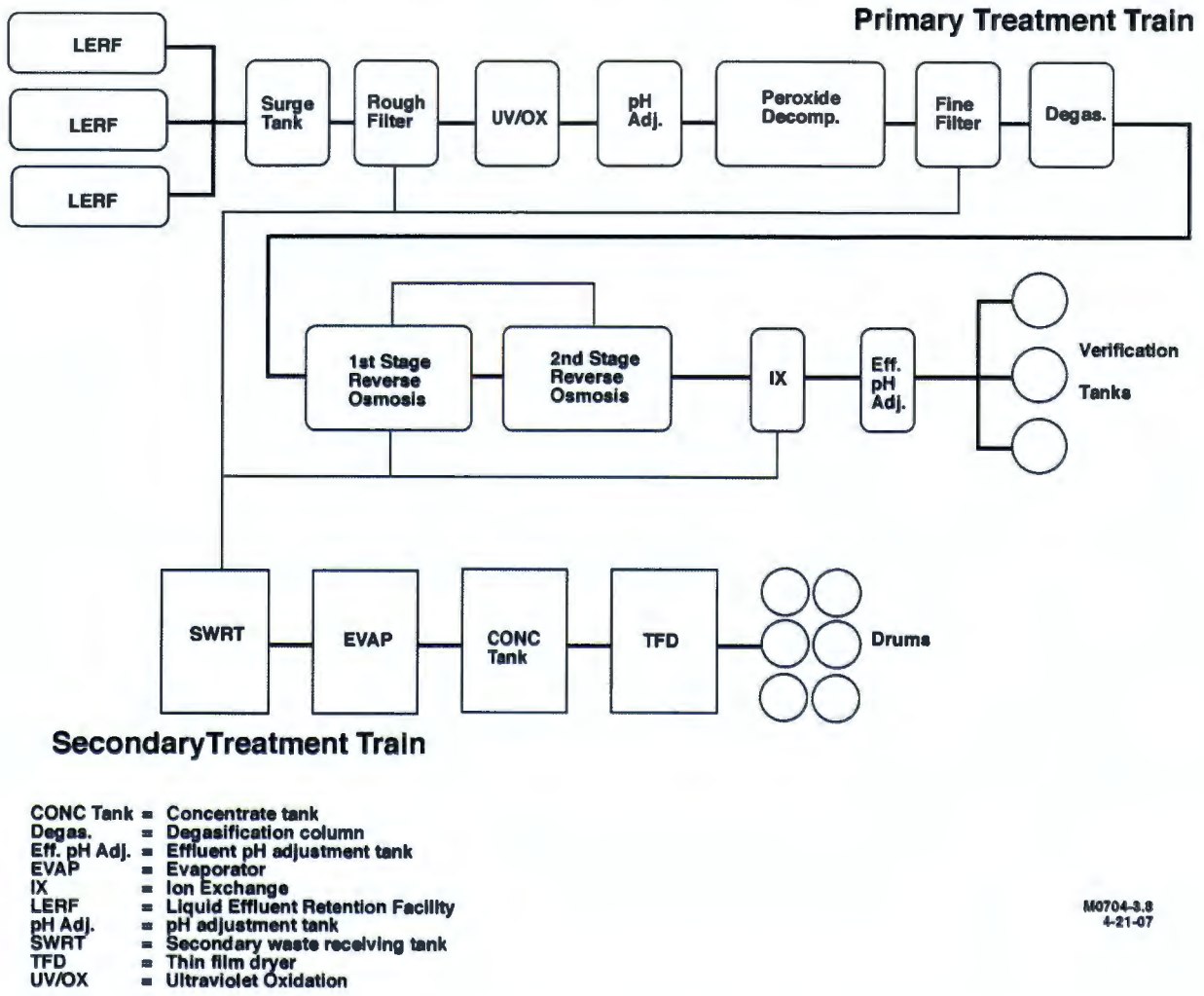


Figure C.4. Example - 200 Area Effluent Treatment Facility Configuration 1

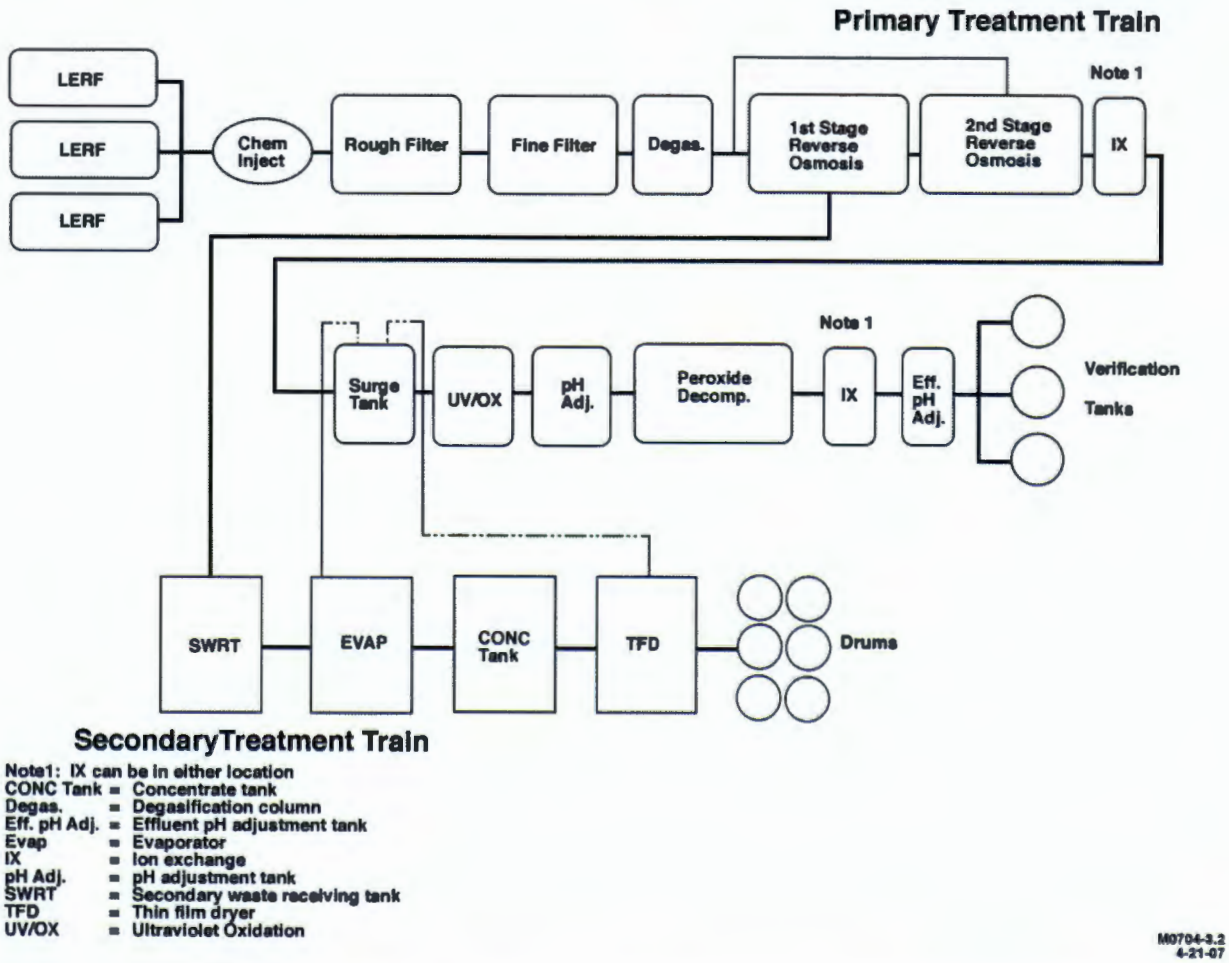


Figure C.5. Example - 200 Area Effluent Treatment Facility Configuration 2

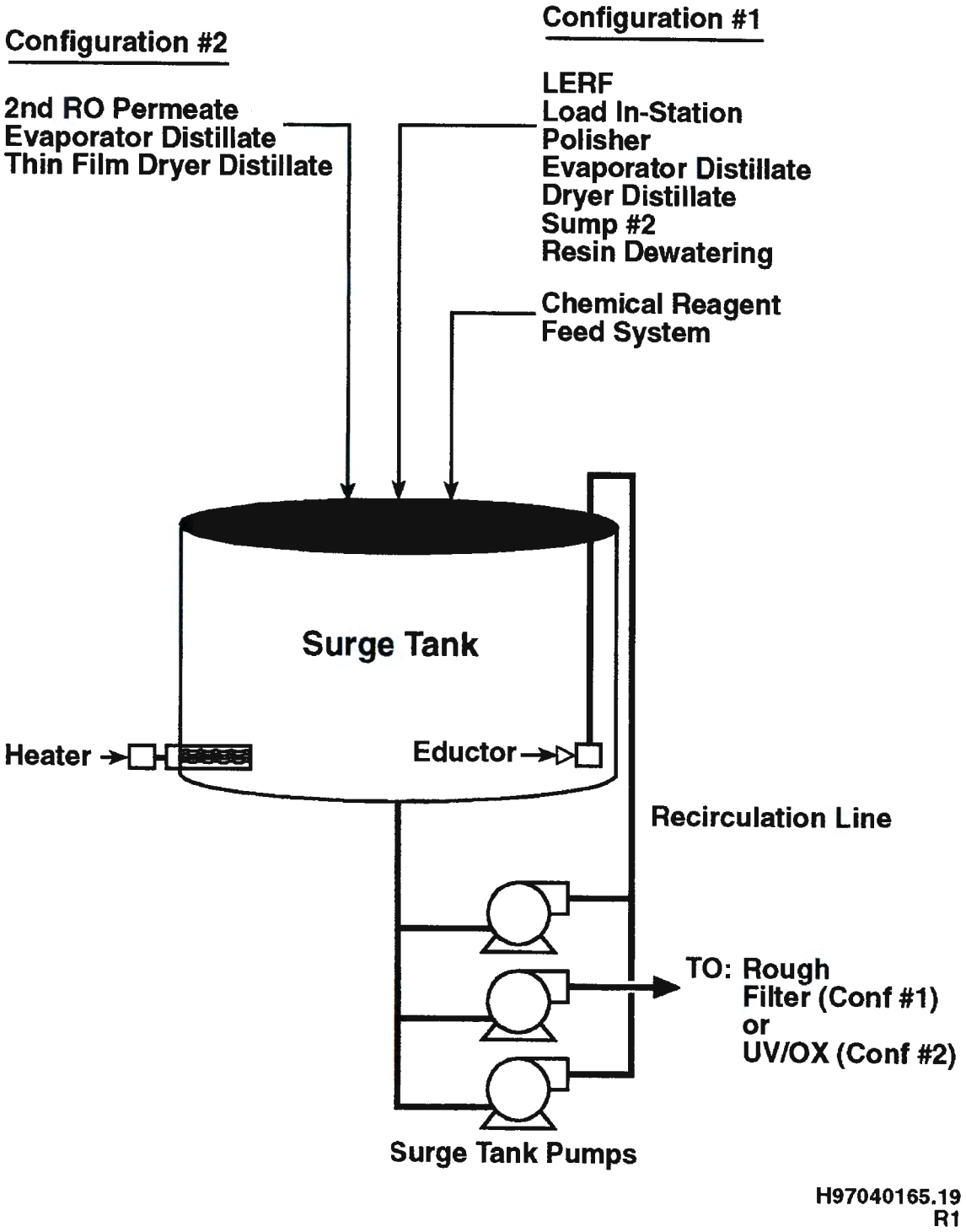


Figure C.6. Surge Tank

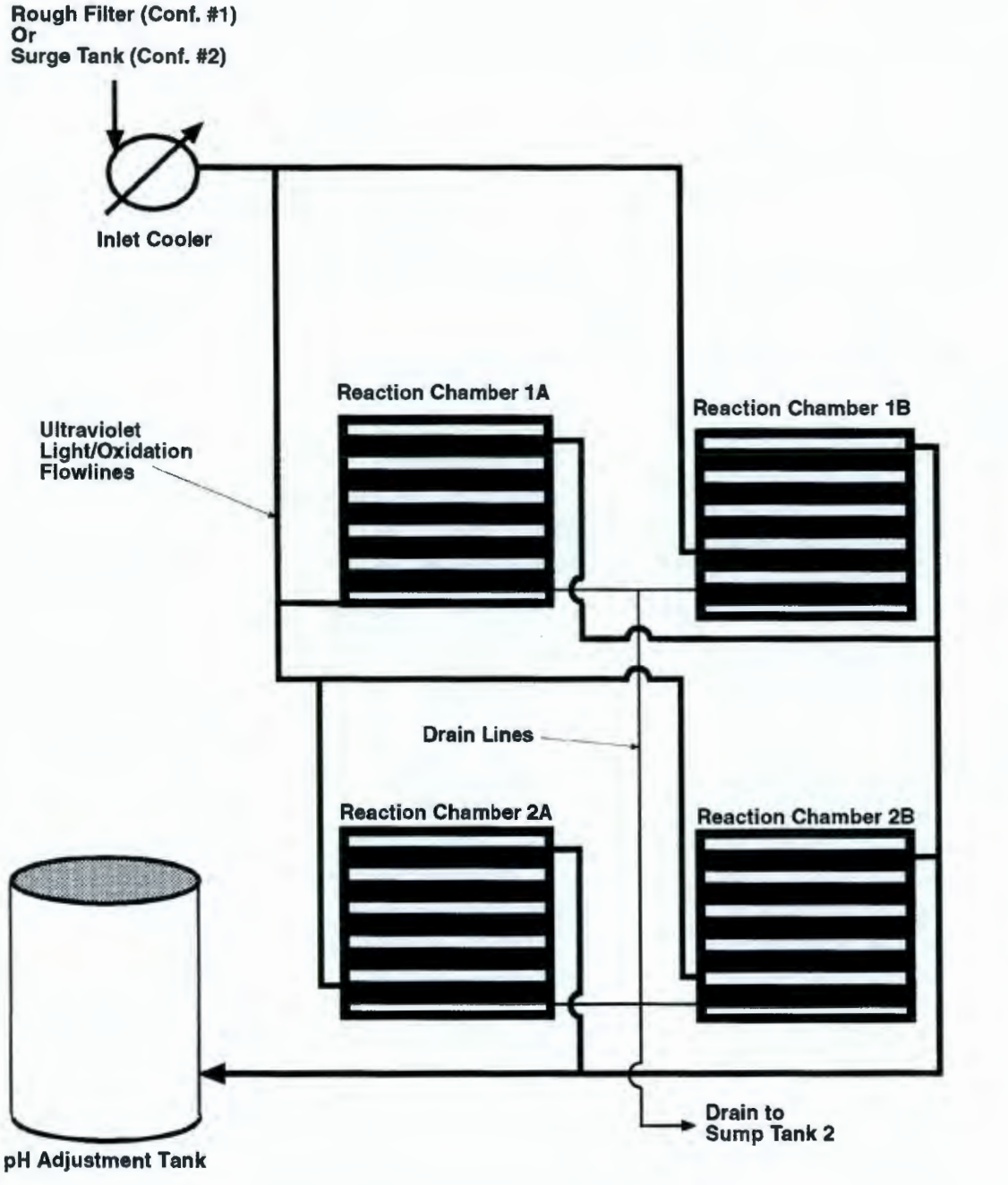


Figure C.7. Ultraviolet Light/Oxidation Unit

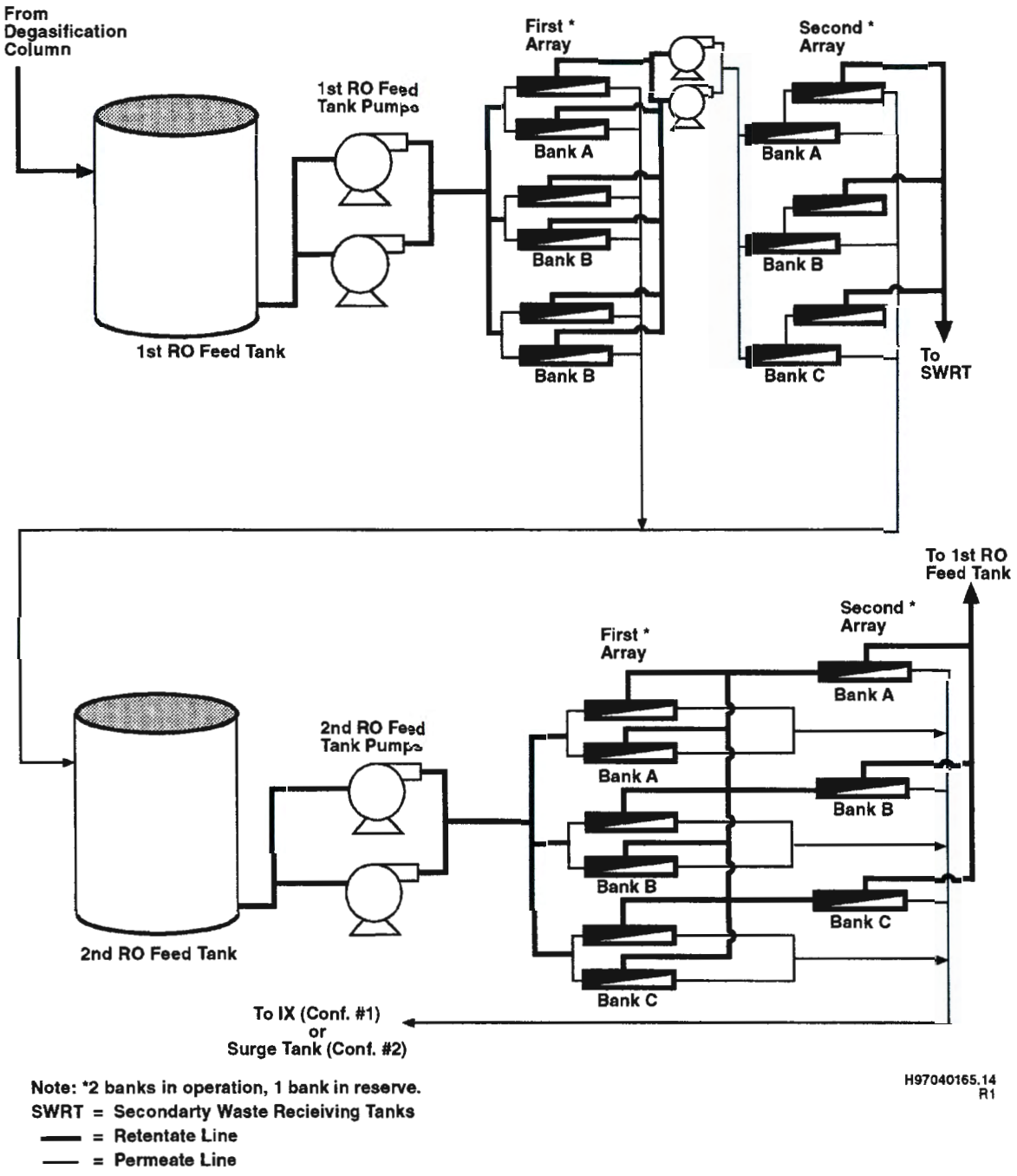
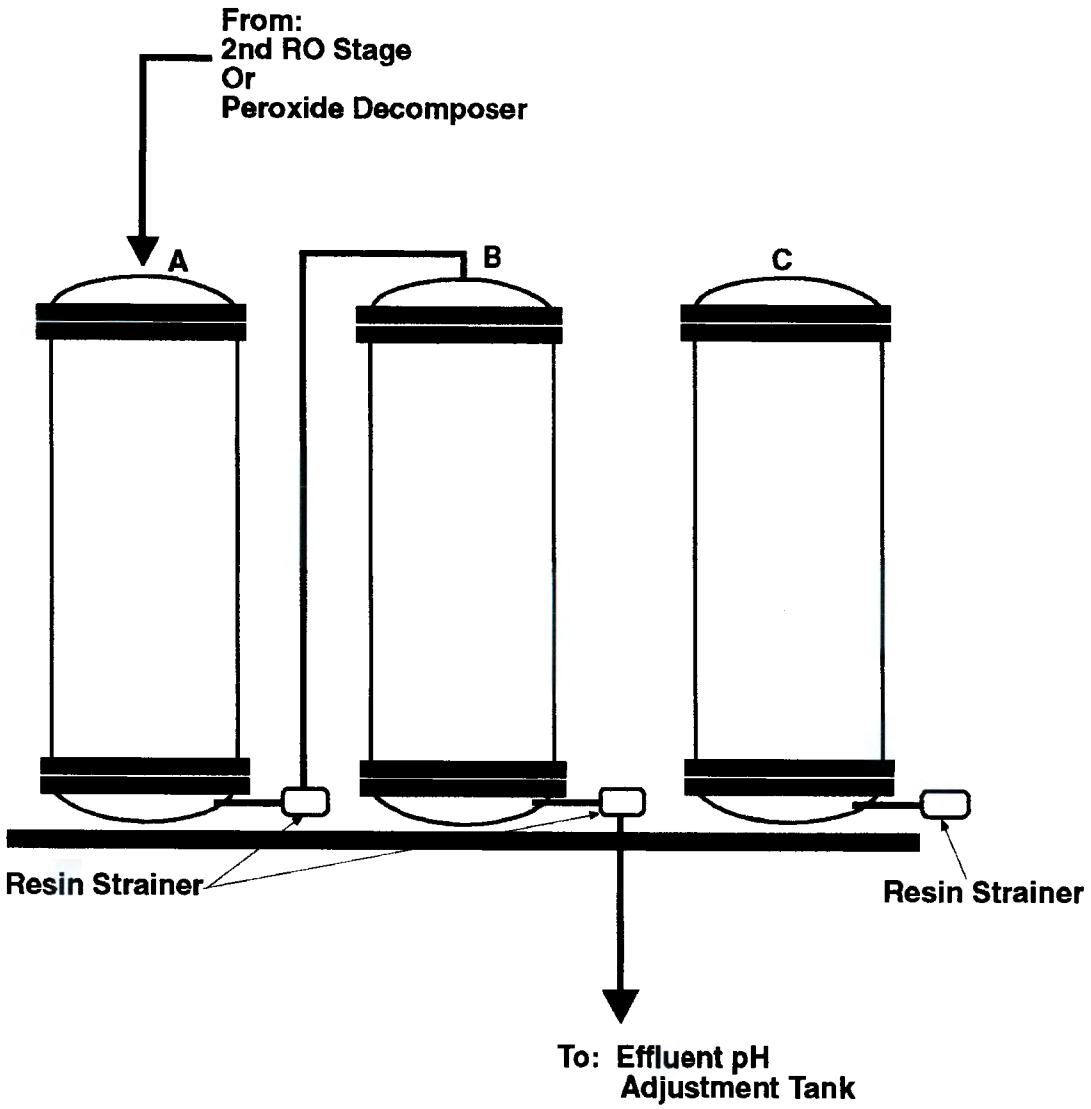


Figure C.8. Reverse Osmosis Unit



NOTE: Example Configuration- Column A and B in Operation, Column C in Standby Mode

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Figure C.9. Ion Exchange Unit

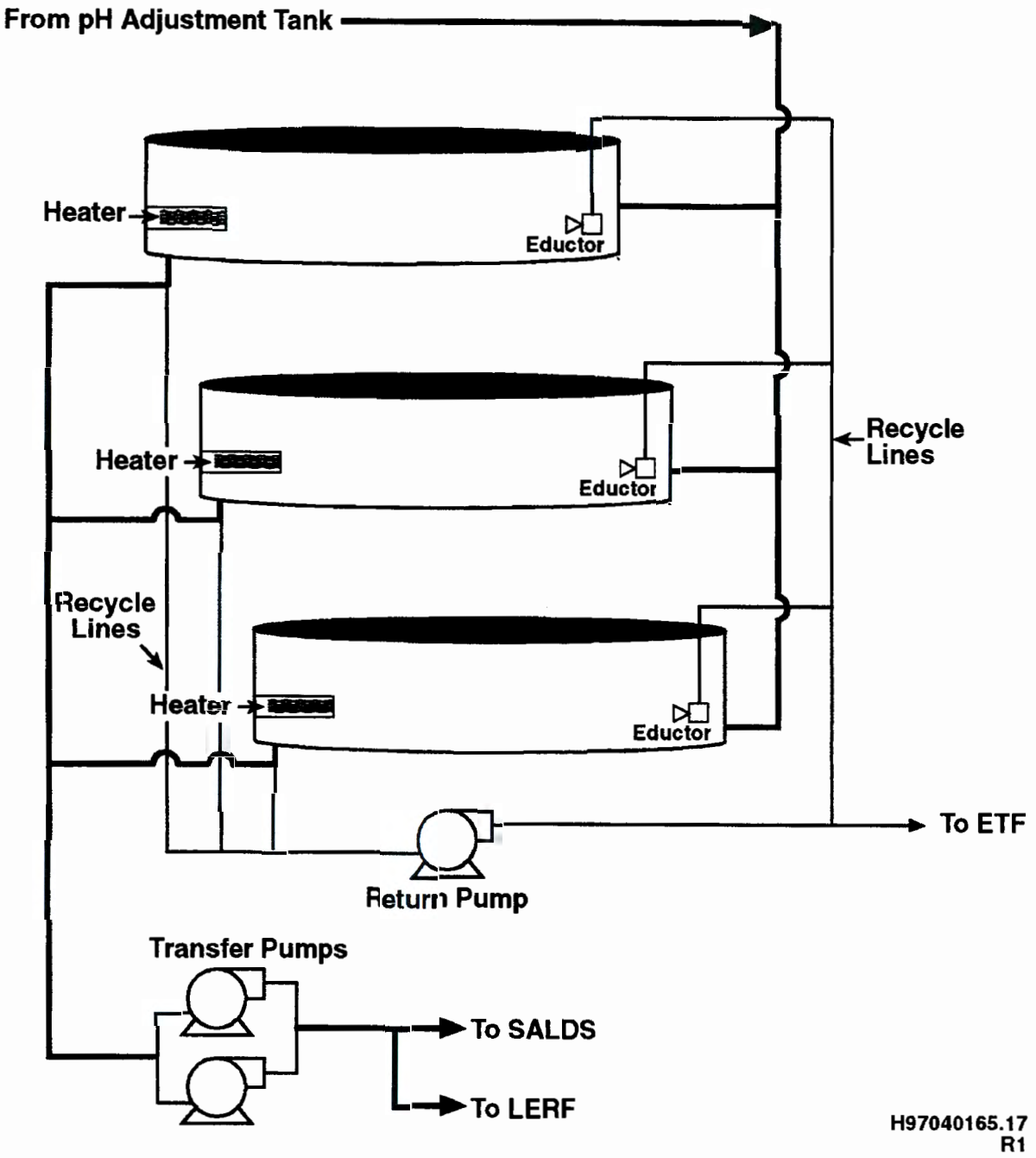


Figure C.10. Verification Tanks

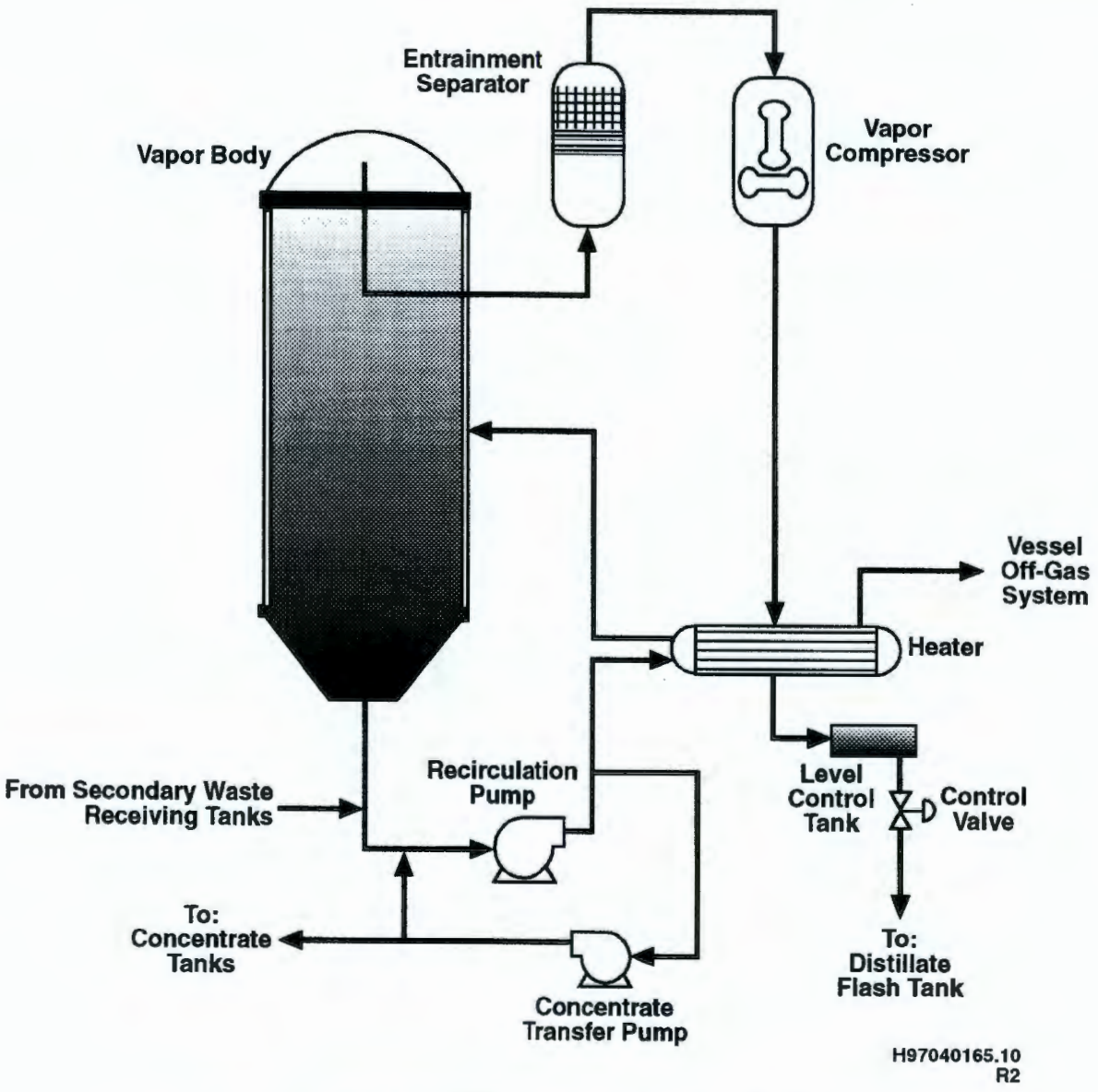


Figure C.11. 200 Area Effluent Treatment Facility Evaporator

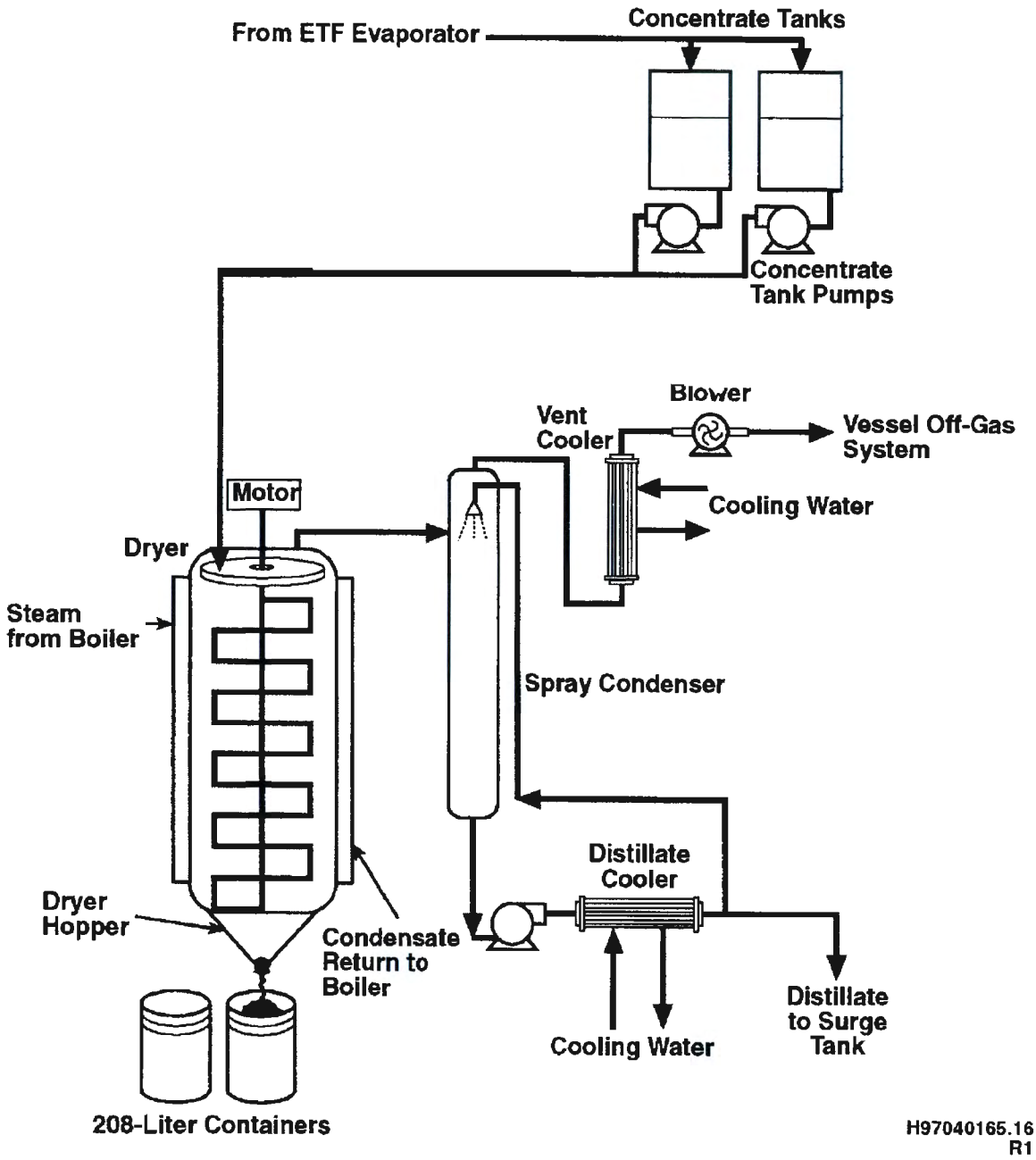
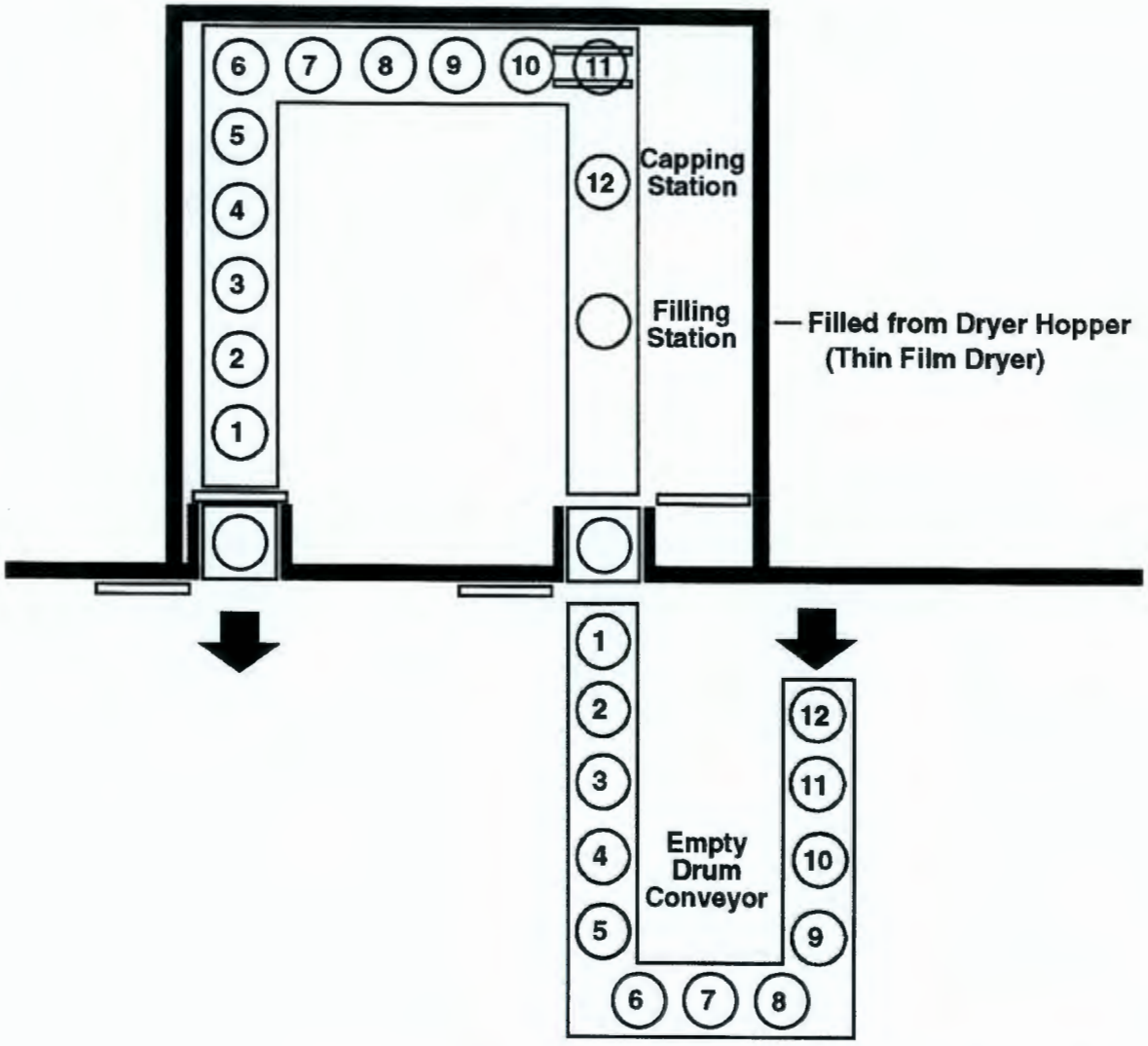


Figure C.12. Thin Film Dryer



1 **Figure C.13. Container Handling System**

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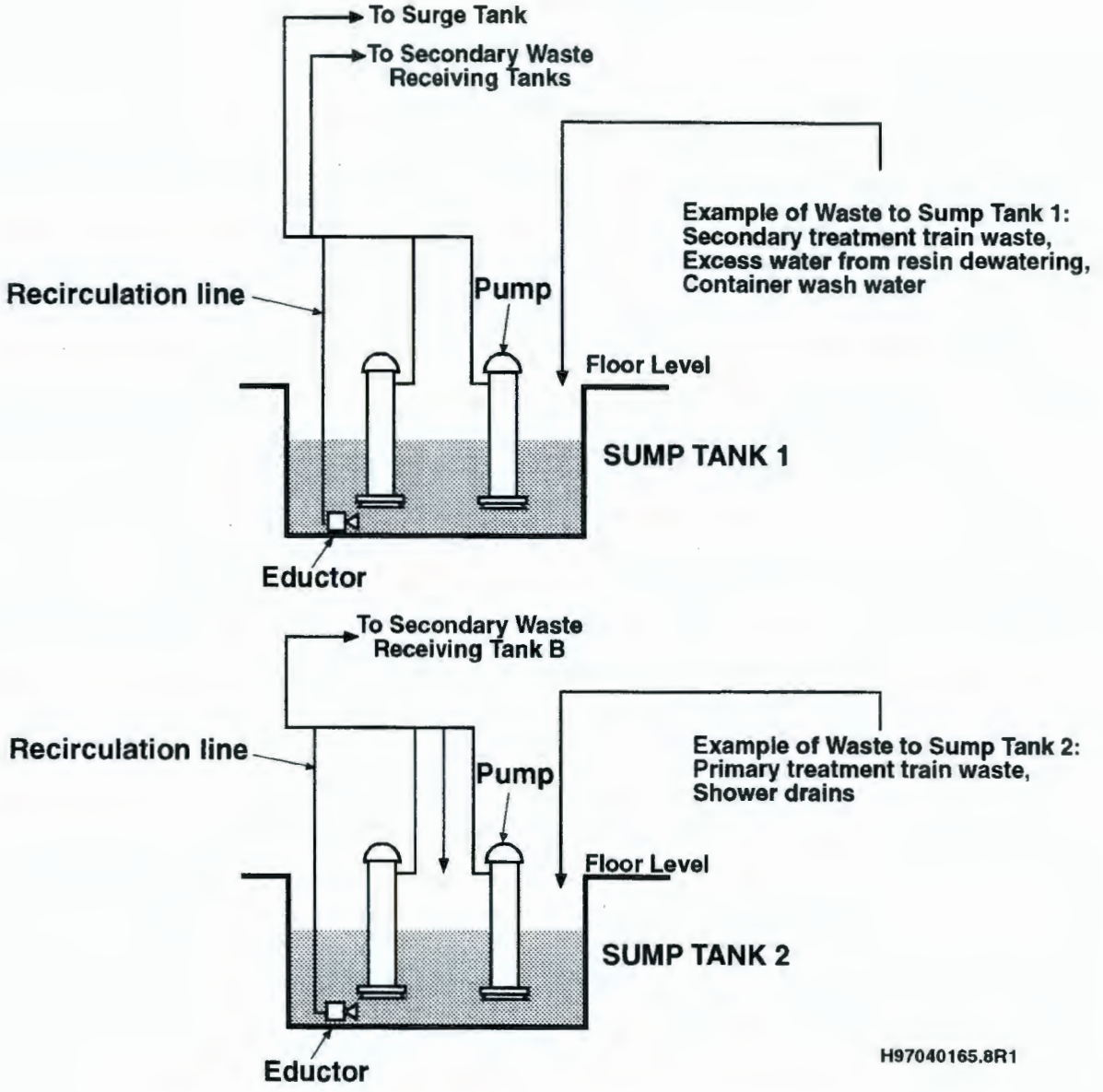

1 **Figure C.14. 200 Area Effluent Treatment Facility Sump Tanks**

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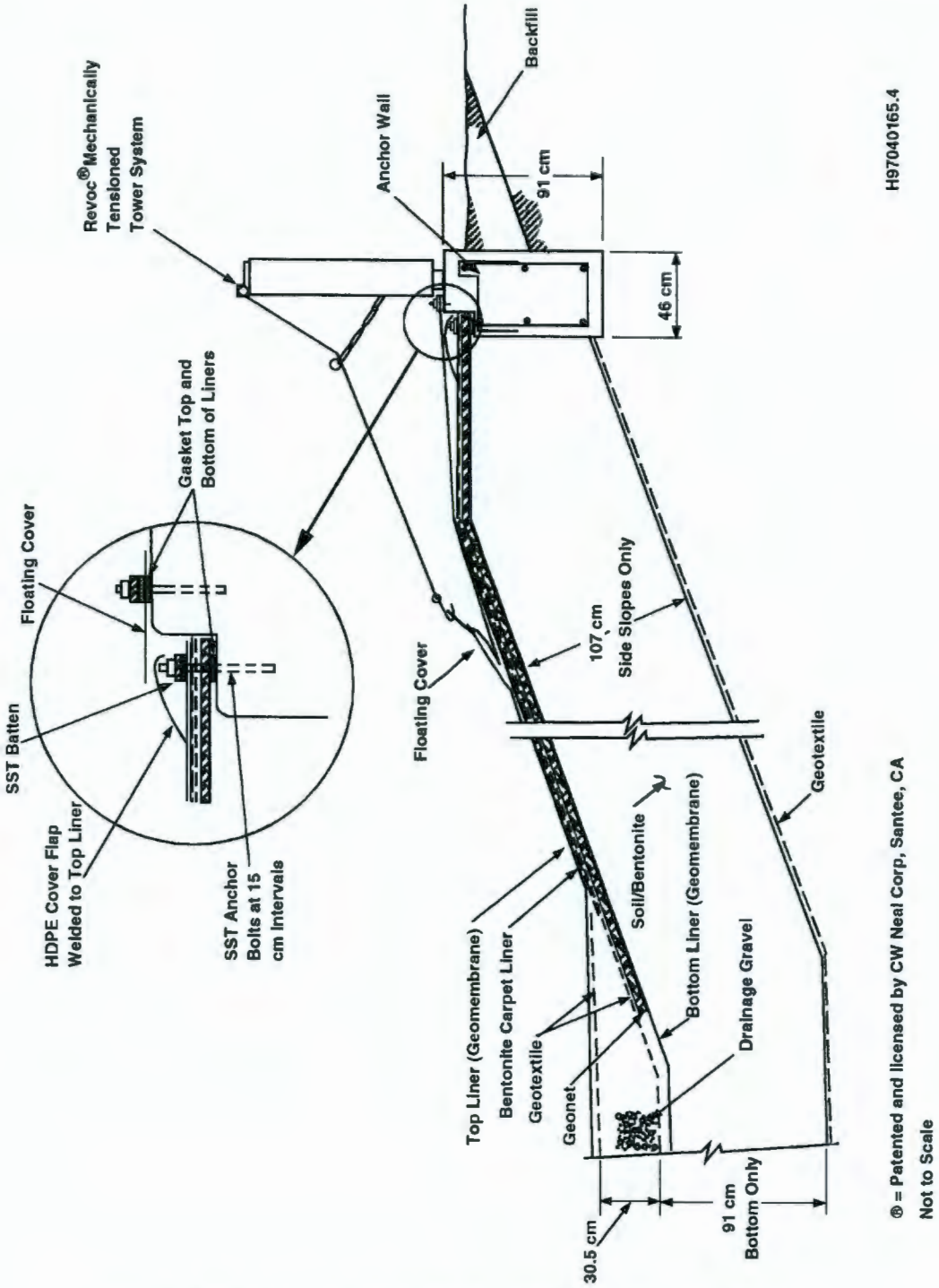

Figure C.15. Liner Anchor Wall and Cover Tension System

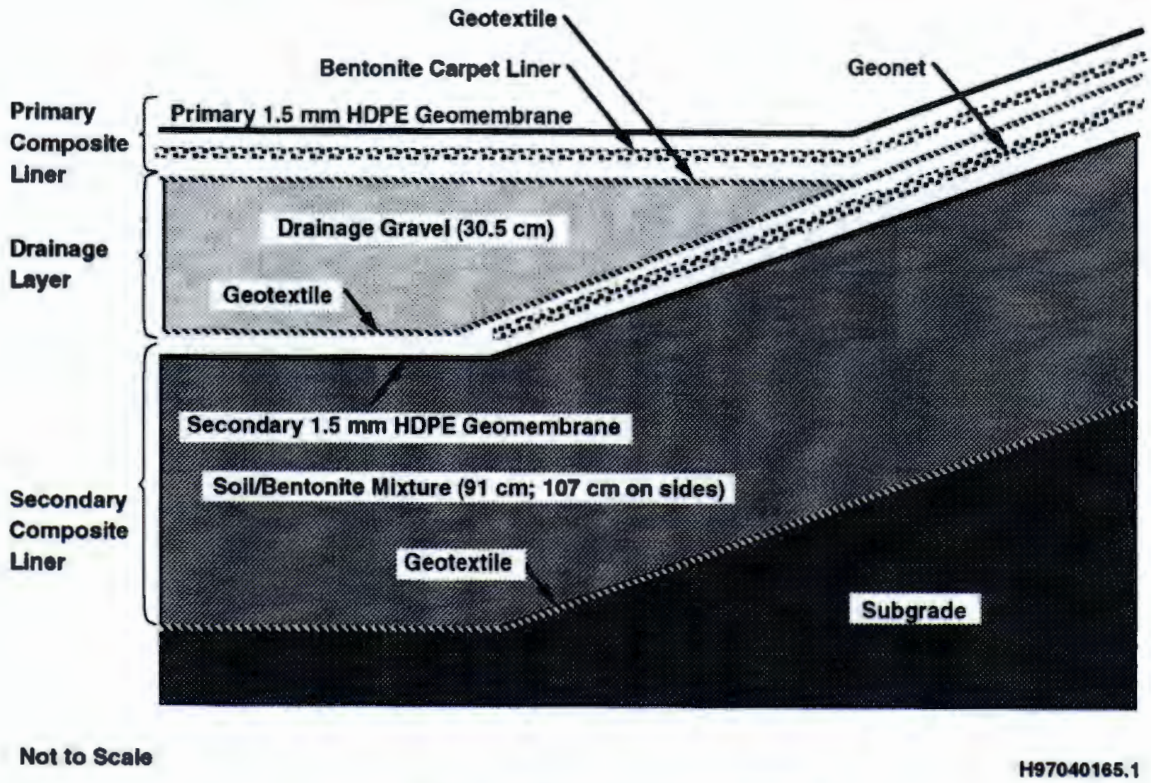

Figure C.16. Liner System Schematic

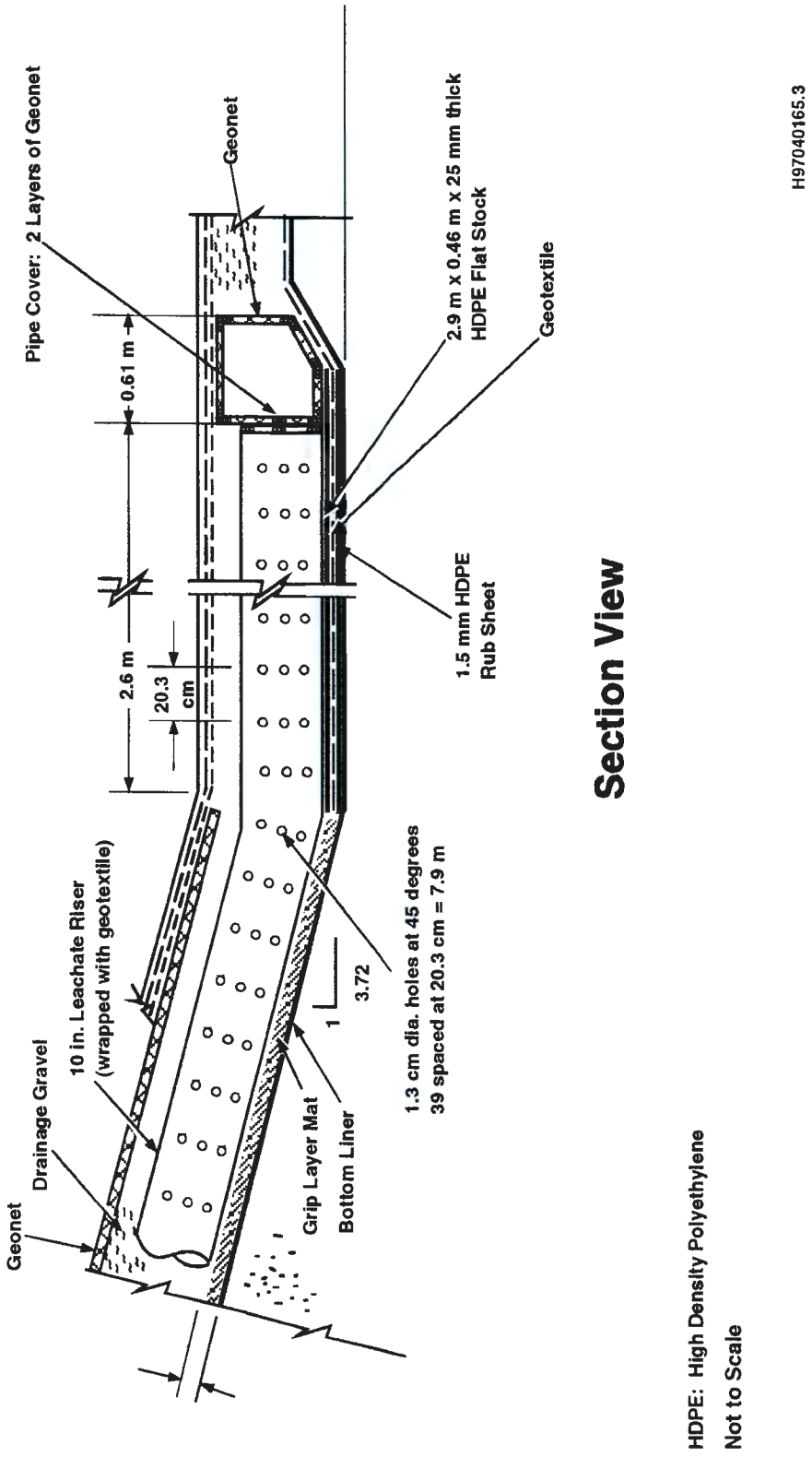

Figure C.17. Detail of Leachate Collection Sump

ADDENDUM F
PREPAREDNESS AND PREVENTION

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ADDENDUM F
PREPAREDNESS AND PREVENTION

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F. PREPAREDNESS AND PREVENTION

F.1 Preparedness and Prevention Requirements

The following sections document the preparedness and prevention measures taken at LERF and 200 Area ETF.

F.1.1 Equipment Requirements

The following sections describe the internal and external communications systems and the emergency equipment required that could be activated by the LERF and 200 Area ETF Building Emergency Director (BED).

F.1.1.1 Internal Communications

When operators are present at the LERF, the operators carry two-way radios to maintain contact with 200 Area ETF personnel. The operators at LERF are informed of emergencies (e.g., building and/or area evacuations, take-cover events, high airborne contamination, fire, and/or explosion), and are provided with emergency instructions by several systems. These systems include the mobile two-way radios, and the telephone in the LERF instrument building.

The 200 Area ETF is equipped with an internal communication system to provide immediate emergency instruction to personnel. The onsite communication system at the 200 Area ETF includes telephones, mobile two-way radios, a public address system, and alarm systems. The telephone and radio systems provide for internal and external communication. Alarm systems exist to allow personnel to respond appropriately to various emergencies, including building evacuations, take cover events, and fire and/or explosion. Addendum J provides additional information on the response activities.

F.1.1.2 External Communications

The LERF and its operators are equipped with devices for summoning emergency assistance from the Hanford Fire Department, the Hazardous Materials Response Team, and/or Hanford patrol, as necessary. External communication to summon emergency assistance is made by a normal telephone system or mobile two-way radios. The LERF telephone is available in the instrumentation building. The 200 Area ETF uses fire alarm pull boxes and telephones for external communication and are located at numerous locations throughout the 200 Area ETF.

F.1.1.3 Emergency Equipment

The LERF and 200 Area ETF rely primarily on the Hanford Fire Department to respond to fires and other emergencies as described in Permit Attachment 4, *Hanford Emergency Management Plan*, (DOE/RL-94-02). All LERF and 200 Area ETF operators are familiar with the LERF and 200 Area ETF contingency plans (Addendum J) and are trained in the use of emergency pumping of LERF and 200 Area ETF systems, fire, and communications equipment.

Portable fire extinguishers, fire control equipment, spill control equipment, and decontamination equipment is available at various locations in the 200 Area ETF.

The 200 Area ETF has fire extinguishers, automatic fire suppression systems (200 Area ETF ~~e~~Control ~~r~~Room and electrical room), fire alarm pull boxes, and a water spray system (200 Area ETF operating and administrative portions).

Respirators, hazardous material protective gear, and special work procedure clothing for 200 Area ETF personnel are kept in the change room at the 200 Area ETF. Safety showers are located in convenient locations in the 200 Area ETF, and emergency eyewashes are available for use. Water for these devices is supplied from the 200 Area ETF sanitary water system.

F.1.1.4 Water for Fire Control

A water main is not provided to the LERF. The Hanford Fire Department is equipped with fire engines for fire control for fires requiring high water volume and pressure. The 200 Area ETF is serviced by two 12-inch raw water lines that are tied into the 200 East Area raw water distribution grids. These lines provide a looped configuration that supplies two independent sources of raw water for fire protection and raw water uses. Connections from the 200 Area ETF raw water system supply fire hydrants and the wet pipe sprinkler system. In the event that water pressure is lost, the Hanford Fire Department is equipped with fire engines to provide needed water.

F.1.2 Aisle Space Requirement

The operation of the LERF does not involve aisle space. Nevertheless, the LERF and the individual basins are easily accessible to emergency response personnel and vehicles. A 6.1-meter (20-feet)-wide service road runs along the base of the basin area on the east, south, and west sides within the operational security fence.

Aisle spacing at 200 Area ETF is sufficient to allow the movement of personnel and fire protection equipment in and around the containers. This storage arrangement also meets the requirements of the National Fire Protection Association (NFPA 1996) for the protection of personnel and the environment. A minimum 76-centimeter (30-inch) aisle space is maintained between rows of containers as required by WAC 173-303-630(5)(c).

F.2 Preventive Procedures, Structures, and Equipment

The following sections describe preventive procedures, structures, and equipment.

F.2.1 Unloading Operations, Spill Prevention, and Control

Underground pipelines that transfer aqueous waste to and from the LERF are encased in a secondary pipe. If a leak is detected in a pipeline, flow in the pipeline will be stopped and the cause of the leak investigated and remediated.

If it is required to transfer aqueous waste from one LERF basin to another, existing transfer pumps are used as described in Addendum C.

The ~~200 Area ETF~~ 2025-ED Load-in Station is monitored continuously during tank-filling operations and filling is stopped immediately if leaks occur. Care is taken to ensure that even minor leaks are cleaned up immediately and disposed of in accordance with approved management procedures. Any spill that is determined to be a dangerous waste will be managed according to the requirements of WAC 173-303.

F.2.2 Runoff

The LERF is constructed and operated to ensure that all aqueous waste is contained within the basins. The basins are designed and operated to prevent overtopping. Furthermore, the basins are provided with very low-density polyethylene floating covers to prevent the introduction of precipitation into the basins. The basins also are graded to ensure that all precipitation outside the basins is directed away from the surface impoundments.

The basins are constructed so that the top of the basin dikes are approximately 3 meters (9.8 feet) above grade. The exterior side slopes of the basins have a 2.25 (horizontal) to 1 (vertical) slope. Run-on of precipitation to the basins from the surrounding area is not possible because the surrounding area slopes away from the LERF.

Dangerous waste and hazardous chemical handling areas at the 200 Area ETF are designed to contain spills, leaks, and wash water, thereby preventing run-off and subsequent releases. All dangerous and/or mixed waste loading and unloading areas are provided with secondary containment structures as described in Addendum C, Process Information.

F.2.3 Water Supplies

The LERF uses operating practices, structures, and equipment to prevent the contamination of natural water supplies (i.e., groundwater and surface water). The LERF is monitored continuously in the 200 Area ETF Control Room during liquid waste transfers and at least daily ~~at other times~~ when waste transfers are not occurring to detect abnormal conditions (e.g., leaks), and regularly inspected to detect equipment and structural deteriorations that could allow possible water supply contamination. The basins are provided with a leachate collection system that is designed to contain any leachate generated. These systems, in conjunction with the double-composite liner system and underlying low permeable clay liner, ensure that should a release occur, the release will be fully contained within the basin configuration and, therefore, water supplies will be protected. Addendum J, Contingency Plan, provides information on procedures that are implemented if a release is detected at the LERF.

There are no drinking water wells near the 200 Area ETF. Therefore, a release would not immediately contaminate drinking water supplies. The 200 Area ETF uses operating practices, structures, and equipment to prevent the contamination of natural water supplies (i.e., groundwater and surface water). The 200 Area ETF is continuously monitored in the 200 Area ETF Control Room during liquid waste processing ~~operations~~ and/or Load-In Station operations transfer to detect abnormal conditions and at least daily ~~at other times~~ when waste process and/or waste transfer operations are not occurring, and is inspected regularly to detect equipment and structural deteriorations that could allow spills to the environment. Areas in contact with dangerous and/or mixed waste are monitored continuously in the 200 Area ETF Control ~~r~~Room during Load-in Station and/or 200 Area ETF processing operations through a series of level and pressure indicators, leak detection alarms, equipment failure alarms, and control panel readouts. In addition, the 200 Area ETF is inspected regularly for the presence of leaks or other off normal conditions wherever possible (in all areas that can be safely entered).

In addition to detailed operating practices, structures and equipment are used at the 200 Area ETF to prevent contamination of water supplies. The structures and equipment designed to prevent contamination of water supplies are the same as the structures and equipment used to prevent run-off from dangerous and/or mixed waste handling areas.

F.2.4 Equipment and Power Failure

The storage function of the LERF is not affected by loss of power and a temporary loss of power would not pose a threat to the environment. Loss of electrical power would not cause the storage of the waste to be jeopardized. For process condensate transferred from the 242-A Evaporator, appropriate valving procedures are followed to ensure a smooth restart of the flow to the LERF in the event of a power failure at the 242-A Evaporator.

The 200 Area ETF does not have a standby power source. Power to selected lighting, computers, and process controls is configured with an uninterruptible power supply. During partial loss of normal power, the ~~effected~~ affected pumps and subsystems will be shut down. Complete loss of power to the 200 Area ETF shuts down the entire 200 Area ETF except for the instruments, ~~in the control room~~ connected to the uninterruptible power supply. The uninterruptible power supply provides temporary power to some systems to assist in an orderly shutdown of the process in the event power cannot be restored quickly. Redundant pumps allow the process to continue to operate when only one component is out of service.

When power at the 200 Area ETF is lost, the valves assume a fail-safe position to allow the process to remain in a safe shutdown mode until restoration of power. This action allows the operators to perform equipment surveys during shutdown and to confirm that there are no safety issues because the 200 Area ETF is shut down. Because a power failure would also shutoff flow into the 200 Area ETF, there will not be any increase in volume in any of the holdup basins, tanks, or other systems.

A combination of reliability, redundancy, maintenance, and repair features are used in the 200 Area ETF equipment and systems to minimize random failure of equipment. For crucial systems such as ventilation

filters, redundant trains are provided to mitigate equipment and system failure. Spare parts are maintained for essential production and safety equipment.

F.2.5 Personnel Exposure

At the LERF and 200 Area ETF, operating practices, structures, and equipment are used to prevent undue exposure of personnel to dangerous and/or mixed waste. All personnel handling waste use protective clothing and equipment. All operations are conducted so that exposure to dangerous and/or mixed waste and hazardous materials are maintained ALARA.

Protective clothing and equipment are prescribed for personnel handling chemicals or dangerous waste. Before the start of any operation that could expose personnel to the risk of injury or illness, a review of the operation is performed to ensure that the nature of hazards that might be encountered is considered and appropriate protective gear is selected. Personnel are instructed to wear personal protective equipment in accordance with training, posting, and instructions.

A change trailer at LERF is located between Basins 42 and 43. In addition, the change trailer has an operations office for working with procedures. Exits within the change trailer are clearly marked. A storage building is located within the perimeter fence, northwest of the basins. The LERF storage building also is provided with separate storage areas for clean and contaminated equipment. A decontamination shower and decontamination building is located at the 272-AW Building, approximately 1.6 kilometers (1 mile) from the LERF or at the 200 Area ETF.

The 200 Area ETF has eyewash stations and safety showers in convenient locations for use by personnel. The following structures and equipment were incorporated into the 200 Area ETF design to minimize personnel exposure.

- Offices, 200 Area ETF eControl rRoom, clean- and soiled-clothes storage areas, change rooms, and the lunchroom are situated to minimize casual exposure of personnel.
- Building exit pathways are located to provide rapid egress in emergency evacuations.
- Emergency lighting devices are located strategically throughout the 200 Area ETF.
- Audio and/or visual alarms are provided for all room air samplers, area alarms, and liquid monitors. Visual readouts for these alarm systems are located in less contaminated areas to minimize exposure to personnel.
- Areas for decontaminating and maintaining equipment are provided in contaminated areas to limit the spread of contamination to uncontaminated areas such as the 200 Area ETF eControl rRoom.
- Instrument interlock systems automatically return process operations to a safe condition if an unsafe condition should occur.
- The 200 Area ETF ventilation systems are designed to provide airflow from uncontaminated zones to progressively more contaminated zones.

Whenever possible, exposures to hazards are controlled by accepted engineering and/or administrative controls. Protective gear is used where effective engineering or administrative controls are not feasible.

F.3 Prevention of Reaction of Ignitable, Reactive, and Incompatible Waste

Typically, aqueous waste managed at the LERF or 200 Area ETF does not display the characteristics of reactivity or ignitability. Any aqueous waste streams exhibiting these characteristics are blended or mixed at LERF to a concentration where the waste no longer exhibits reactive or ignitable characteristics.

Incompatible aqueous waste is not expected to be stored or treated at the LERF or 200 Area ETF (Addendum B, Waste Analysis Plan). Therefore, the requirements of WAC 173-303-806(4)(a) are not applicable.

ADDENDUM H
CLOSURE PLAN

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ADDENDUM H
CLOSURE PLAN

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H. CLOSURE PLAN

This addendum describes the planned activities and performance standards for closing LERF and 200 Area ETF.

H.1 Closure Plan

The LERF and 200 Area ETF will be closed by removal or decontamination with respect to dangerous waste contamination that resulted from operation as TSD units, with closure of LERF occurring first. To facilitate closure, the LERF retention basins are being viewed as consisting of seven components: the covers and primary liner, drainage layer system/bentonite carpet liner, secondary liner, soil/bentonite, internal and/or external piping, ancillary equipment, and concrete basins. To facilitate closure of 200 Area ETF, the 200 Area ETF is being viewed as consisting of six components: tanks, internal and/or external piping, ancillary equipment, concrete floors/dikes/ encasements, structures, and soil directly beneath the structure. It is anticipated that closure of LERF and 200 Area ETF will begin after the projected 30-year active life of LERF and 200 Area ETF. If it is determined that closure by removal or decontamination is not possible, the closure plan will be modified to address required post closure activities.

Uncontaminated structures will be left for future use or disassembled, dismantled, and removed for disposal. Uncontaminated equipment and structures could include aqueous makeup, HVAC and piping, steam condensate and cooling water piping, and the 200 Area ETF eControl rRoom and office areas.

Closure by removal or decontamination requires decontamination or removal and disposal of all dangerous waste, waste residues, contaminated equipment, soil, or other material established in accordance with the removal or decontamination closure performance standards of WAC 173-303-610(2). This and future closure plan revisions will provide for compliance with these performance standards.

H.2 Closure Performance Standard

Closure by removal or decontamination, as provided for in this plan based on the requirements of WAC 173-303-610(2), will eliminate future maintenance and will be protective of human health and the environment by removing or reducing chemical contamination at LERF and 200 Area ETF to levels that are below concern with respect to human health and the environment.

This plan proposes to leave clean structures and equipment in place after closure for potential use in future operations. This need will be evaluated at the time of closure.

H.2.1 Closure Standards for Metal Surfaces, Rubber, Tanks, and Concrete

This closure plan proposes use of a 'clean debris surface' (defined in the following paragraph) as the clean closure performance standard for the metal surfaces, rubber (i.e., basin covers, liners, etc.), tanks, and concrete that will remain after closure. This approach is consistent with Ecology guidance (Publication- #94-111, Ecology 2005) for achievement of clean closure. Additionally, adherence to this guidance ensures that all residues have been removed as required by WAC 173-303-640 for closure of the 200 Area ETF tank systems.

The clean debris surface standard is verified visually. *A clean debris surface means the surface, when viewed without magnification, shall be free of all visible contaminated soil and hazardous waste except residual staining from soil and waste consisting of light shadows, slight streaks, or minor discolorations and soil and waste in cracks, crevices, and pits may be present provided that such staining and waste and soil in cracks, crevices, and pits shall be limited to no more than 5% of each square inch of surface area* (40 CFR 268.45). When a physical extraction method is used on concrete, the performance standard is based on removal of the contaminated layer of debris. The physical extraction performance standard for concrete is removal of 0.6 centimeter (0.25 inches) of the surface layer and treatment to a clean debris surface. Inspections to verify achievement of a clean debris surface will be performed and documented.

H.2.2 Closure Standards for Piping and Ancillary Equipment

The internal and external piping of both LERF and 200 Area ETF that has contacted dangerous waste will be flushed and drained as part of closure. When practical, ancillary equipment, which has contacted dangerous waste will also be flushed and drained. For piping and ancillary equipment where the contaminated surfaces can be inspected, an inspection will be performed to see if the surfaces meets the clean debris surface standard in 40 CFR 268.45, incorporated by reference by WAC 173-303-140, and can be declared non-dangerous in accordance with WAC 173-303-071(3)(qq). If it is not possible to inspect the contaminated surfaces or meet the clean debris surface performance standard, the particular piping or ancillary equipment of concern will be removed, designated, and disposed of accordingly.

Dangerous and/or mixed-waste materials generated during closure activities will be managed in accordance with WAC 173-303-610(5). Removal of any dangerous wastes or dangerous constituents during partial or final closure will be handled in accordance with applicable requirements of WAC 173-303-610(5).

H.2.3 Closure Standards for Underlying Soils

The LERF retention basins have a leachate collection system that channels the leachate to sumps at the bottom of the basins. The collected liquid is pumped back into the basins, thereby limiting fluid head on the secondary liner. The secondary liner is comprised of several protective layers, including a high-density polyethylene geomembrane and a soil/bentonite admixture. The soil below the LERF only could be contaminated if the layers of the secondary liner had failed. The primary liner and the drainage gravel, geotextile, and geonet between the primary and secondary liners cannot easily be decontaminated. The high-density polyethylene layer of the secondary liner also cannot be decontaminated. These materials will be removed and disposed according to the requirements of WAC 173-303-170. The soil/bentonite admixture will be sampled and analyzed for constituents of concerns according to the sampling and analysis plan developed prior to the time of closure. If the analytical results determine that the constituents of concern are at or below the levels in WAC 173-303-610(2)(b)(i), or background levels for Hanford soil if background is greater, the soil/bentonite admixture and the soil below LERF will be considered clean closed.

Clean closure of soil under the 200 Area ETF will be accomplished by demonstrating that the coated concrete floor kept contaminants from reaching the soil. The coated concrete floor provided secondary containment for all the tanks and process piping. Unless inspections identify potential through-thickness cracks indicating containment failure and a subsequent potential for soil contamination from TSD unit operations, the soil will be considered clean closed. However, if inspections identify such cracks and there have been documented spills in the vicinity, potential soil contamination will be investigated. Soils will be sampled and analyzed for constituents of concern according to the sampling and analysis plan. The sampling and analysis plan will be prepared following the completion of a data quality objectives process in accordance with EPA/600/R-96/055 (QA/G-4), *Data Quality Objectives Process*, as amended. The data quality objectives process will be initiated prior to closure on a schedule to ensure timely closure of LERF. The sampling and analysis plan will be submitted to Ecology as part of a permit modification request meeting the requirements of WAC 173-303-830. The sampling and analysis plan will be prepared consistent with EPA/240/B-01/003 (EPA/ QA-/R-5), *EPA Requirements for Quality Assurance Project Plans*, as amended.

If the soil analytical results determine that the constituents of concern are at or below the levels in WAC 173-303-610(2)(b)(i), or background levels in the Hanford soil if background is greater, the soil will be considered clean closed. If the constituents of concern exceed background levels, the soil will be closed per the standards of WAC 173-303-610(2)(b).

H.3 Closure Activities

The LERF and 200 Area ETF were designed for a 30-year active life. At the time of closure, the closure plan will be modified as necessary to reflect current regulation or informational revisions in accordance

with WAC 173-303-610(3)(b). If it is determined that clean closure is not possible, the closure plan will be modified to address required post closure activities.

H.3.1 General Closure Activities

The approach to LERF closure is to dispose of accumulated basin aqueous waste by processing the waste through 200 Area ETF. Primary basin liners, covers, drainage gravel, geonets, and secondary HDPE liners will be removed, designated, and disposed of as described in Sections ~~G~~H.3.4.1 and H.3.4.2. Any remaining solids (residue) within the basins will also be removed, designated, and disposed of accordingly. Piping associated with LERF closure is intended to be decontaminated, drained, and inspected. Piping that meets the closure standard in Section ~~G~~H.2.2 will be left in place. Piping that does not meet the closure standard, or cannot be inspected, will be disposed of accordingly. Rinsate generated during decontamination also will be disposed of through 200 Area ETF. Sampling will assess whether contamination beneath the secondary HDPE liner has occurred. Contamination above background levels, if present, will be removed or decontaminated to meet the regulatory requirements of WAC 173-303-610(2)(b).

The approach to 200 Area ETF closure is to process any aqueous waste through the effluent treatment system. Any waste, which cannot be treated at 200 Area ETF as the facility is being closed, will be transferred to other TSD units or off-site TSD facility. Piping will be rerouted and temporary piping installed to allow the isolation of tanks and ancillary equipment for draining, decontamination, and closure. Rerouted and temporary piping will be closed in the same manner as process piping. All structures and equipment will be decontaminated to the closure standards in Section ~~G~~H.2.2 or disposed. Piping associated with 200 Area ETF closure is intended to be decontaminated, drained, and inspected. Piping that meets the closure standard in Section ~~G~~H.2.2 will be left in place. Piping that does not meet the closure standard, or cannot be inspected, will be disposed of accordingly. Contamination, if present, will be managed in compliance with regulatory requirements.

Equipment or materials used in performing closure activities will be decontaminated or disposed at a permitted facility.

H.3.2 Constituents of Concern for Closure for the Liquid Effluent Retention Facility and 200 Area Effluent Treatment Facility

Using the list of dangerous waste numbers in the Addendum A, Part A Form, constituents in the final delisting in 40 CFR 261 Appendix IX, sample results from wastes added to LERF and 200 Area ETF, process knowledge and the risk to human health and the environment, the constituents of concern for closure will be determined through the data quality objective process. Based on constituents in wastewater received at LERF from 2000 to 2006 which are present at five percent of their delisting levels or higher, the constituents of concern are:

- Acetone
- Ammonia
- Barium
- Chromium
- Carbon tetrachloride
- Fluoride
- Lead
- Mercury
- Methyl ethyl ketone
- n-Butyl alcohol
- Total cresols
- Tributyl phosphate
- Vanadium

Arsenic and beryllium are excluded because they are present in Hanford soils and may therefore give a false positive sample result. Constituents of concern vary in each basin. For example, ammonia may be present only in LERF Basin 42. The constituents of concern for each basin will be determined by process knowledge as part of the Data Quality Objectives process for the Sampling and Analysis Plan.

H.3.3 Removing Dangerous Waste

At the start of LERF closure, aqueous waste will be transferred sequentially from each basin to another LERF basin or to 200 Area ETF for treatment. At a pump rate of about 284 liters (75 gallons) per minute, it will take approximately 60 days to empty a full basin. Basin covers will remain in place to prevent possible wind dispersion of waste until all basin waste has been removed.

All of the aqueous waste inventory at the 200 Area ETF will be processed before closure. Any residue remaining in piping, equipment, or the LERF liner will be removed to an appropriate disposal unit. All containerized waste will be dispositioned. All secondary waste in containers will be transferred to an appropriate TSD unit.

H.3.4 Decontaminating Structures, Equipment, and Soils

This section discusses the activities necessary to implement a clean closure strategy for the LERF and 200 Area ETF.

H.3.4.1 Covers and Primary Liner

The following steps will be performed to close each LERF basin cover and primary liner:

- Wastewater will be removed from the basins and transferred to another LERF basin or to 200 Area ETF. Additional pumps and piping may be installed to empty the basin as low as possible.
- The basin cover will be cut into pieces and disposed in containers.
- As much as practical of the remaining residue within the basins will be removed and transferred to containers, another LERF basin, or 200 Area ETF. Rinsing may be performed to facilitate removal.
- The pipe risers, transfer pump, HDPE primary liner and bentonite carpet liner will be cut into pieces and disposed in containers.

H.3.4.2 Drainage Layer and Secondary Liner

The following steps will be performed to close each LERF basin drainage layer and secondary liner:

- The drainage gravel, geotextile, and geonet will be cut into pieces, and disposed in containers.
- As much as practical of the remaining residue on the secondary liner will be removed and transferred to containers, another LERF basin or 200 Area ETF. Rinsing may be performed to facilitate removal of residue.
- The HDPE liner portion of the secondary liner will be visually inspected for physical damage. This will provide potential sampling locations to determine if the soil/bentonite below the HDPE liner may be clean closed.
- The leachate pump, pump riser, and HDPE liner portion of the secondary liner will be removed, cut into pieces, and disposed in containers.
- The soil/bentonite portion of the secondary liner will be visually inspected for signs of contamination. This will provide potential sampling locations to determine if the soil/bentonite may be clean closed.

Assessment of contamination beneath the LERF's secondary liner will be performed within each basin by sampling the top surface of the ~~97~~91-centimeter (36-inch) thick layer of soil/bentonite. Biased and random location selection will be used to increase the probability of detecting leachate contamination. Some sampling points will be chosen randomly, while others will be chosen where physical damage was noted during the inspection of the secondary HDPE liner and soil/bentonite layer, and in areas where the underlying material porosity and permeability and the hydraulic head would most likely drive any leachate. The leakage rate through the liner would increase toward the bottom of the liner as hydraulic head increases. Any leakage that did occur in the sloped sides could be expected to travel down slope through the geotextile between the primary and secondary liner until reaching the bottom of the liner. Therefore, the most likely area of contamination would be the soil/bentonite in the leachate sump and at the bottom of the basin. Sampling and disposal objectives will be determined at the time prior to closure activities through the data quality objectives process. The sampling and analysis plan will be prepared following the completion of a data quality objectives process in accordance with EPA/600/R-96/055 (QA/G-4) *Data Quality Objectives Process*, as amended. The data quality objectives process will be

initiated prior to closure on a schedule to ensure timely closure of LERF. The sampling and analysis plan will be submitted to Ecology as part of a permit modification request meeting the requirements of WAC 173-303-830. The sampling and analysis plan will be prepared consistent with EPA/240/B-01/003 (EPA/ QA-/R-5), *EPA Requirements for Quality Assurance Project Plans*, as amended.

Sampling of the soil/bentonite will be performed in accordance with the sampling methods allowed for in WAC 173-303-110(2). Special care will be needed in sampling for volatiles. To aid in ensuring sample integrity, the initial sampling of the soil/bentonite may proceed while the secondary HDPE liner is in the process of being removed.

If no constituents of concern are found above soil closure performance standards (Section ~~G~~H.2.3), no further analysis will be done. If the initial sample analysis indicates liner leakage, additional samples from different depths and locations will be taken to determine the spatial extent of contamination. The soil/bentonite will be removed in the area around the contamination and placed in containers. If contamination is found to extend through the entire depth of the soil/bentonite layer, soil beneath the basin that is contaminated above closure performance standards will also be removed and placed in containers.

H.3.4.3 Tanks

The following general steps will be performed to close, each 200 Area ETF tank and ancillary equipment:

- Wastewater and chemical additions to the tank will be isolated or rerouted to a downstream tank.
- Piping and ancillary equipment associated with the tank will be flushed with water and drained to the tank being closed, to another tank, or to containers.
- Wastewater will be removed from the tank and transferred to another tank. Additional pumps and piping may be installed to empty the tank as low as possible.
- All remaining residue at the bottom of the tank will be removed and transferred to another tank or containers. Rinsing may be performed to facilitate removal of residue.
- An initial visual inspection of the tank's interior and exterior surfaces will be performed to determine the type of flushing that will allow the tank to be clean closed, or whether the tank cannot be clean closed.
- The tank's surfaces, piping and ancillary equipment will be cleaned by chemical or physical extraction techniques described in 40 CFR 268.45. Flush solution will be transferred to another tank or containers. All flush solution at the bottom of the tank will be removed before visual inspection.
- The tank, piping, and ancillary equipment will be inspected visually for compliance with the performance standard in Sections H.2.1 and H.2.2.

Closure will begin with the Load-In Station tanks, surge tank, and other tanks of the main treatment train. The secondary treatment train will operate as long as possible to reduce the volume of flush water requiring disposal. Condensate from the secondary treatment train will be routed to the main treatment train or the verification tanks for storage or treatment.

After rinsing, the tanks will be inspected visually for compliance with the performance standard. Visual inspection might be made remotely using a camera or other device that allows verification of meeting the performance standard. If any areas are found not meeting the clean debris surface performance standard, these areas will be decontaminated in-place, or the contaminated portions will be removed, designated, and disposed accordingly. Per 40 CFR 268.45, Table 1 incorporated by reference at WAC 173-303-140, only removal of contaminants from the surface layer is necessary for metal surfaces.

The outside of the tanks also will be inspected for compliance to the performance standard. Any areas found not to meet this performance standard will be decontaminated in-place, or the contaminated portions will be removed, designated, and disposed accordingly. Before using decontamination solutions

on the outside of the tanks, the floor will be inspected for cracks or other openings that could provide a pathway to soil. This inspection will be performed as described in Section ~~G~~H.2.3 in conjunction with mapping of potential through-thickness cracks. Any such cracks will be mapped. The cracks will be sealed before beginning treatment or other engineered containment devices (e.g., portable catch basins, liners) will be used to collect and contain solutions.

Decontamination residues will be collected, designated, and managed as appropriate. If it is not possible to meet the clean closure performance standard, contaminated portions of the tanks could be removed, designated, and disposed of accordingly. The inspections for a clean debris surface will be documented on an inspection record.

H.3.4.4 Internal and External Piping and Ancillary Equipment

The internal piping and ancillary equipment for both LERF and 200 Area ETF, which have contacted dangerous waste will be flushed and drained as part of closure. Any treatment media, such as filters, reverse osmosis membranes, ion exchange resins, will be removed from the ancillary equipment, and disposed of accordingly. Where the contaminated surfaces can be inspected, an inspection will be performed to see if the piping and ancillary equipment meet the clean debris surface standard in 40 CFR 268.45 and can be declared non-dangerous. If it is not possible to meet the clean debris surface standard or the piping or ancillary equipment cannot be inspected, those portions of the piping and ancillary equipment will be removed, designated, and disposed of accordingly.

External piping (transfer lines) associated with LERF and 200 Area ETF consist of below grade and above grade piping. Below grade, piping will be dispositioned at closure consistent with the practices for below grade piping in the 200 Areas at the time of closure consistent with the 200-IS-1 operable unit decisions. Above grade piping will be dispositioned consistent with the provisions for internal piping.

Rinsate from the LERF and 200 Area ETF external piping and LERF internal piping will be processed through 200 Area ETF. Dangerous and/or mixed-waste solutions and materials generated during closure activities, which cannot be treated at 200 Area ETF will be managed in accordance with WAC 173-303-610(5).

H.3.4.5 Concrete

At LERF, the concrete catch basins are located at the northeast corner of each retention basin, where inlet pipes, leachate risers, and transfer pipe risers emerge for the basin. The concrete catch basin is curbed, and coated with a chemical resistant epoxy sealant. The concrete catch basin is sloped so that any leaks or spills from the piping or connections will drain into the basin. At the 200 Area ETF, the coated concrete floor and berm provides secondary containment for all the tanks and process piping.

Closure of concrete at LERF and 200 Area ETF will be performed after the associated tanks, piping, ancillary equipment, and structures have been closed. All concrete will be inspected visually and surveyed before any decontamination. The purpose of the inspection will be twofold: to identify and map any cracks in the concrete that might have allowed contaminants a pathway to the soil below (Section ~~G~~H.2.3~~.~~), and to identify areas that potentially are contaminated with dangerous waste or dangerous waste residues. The inspection standard will be a clean debris surface as defined in Section ~~G~~H.2.1. The inspection of the concrete for a clean debris surface will be documented on an inspection record. Those areas already meeting the standard can be clean closed as is.

Those potentially contaminated areas will undergo decontamination to meet the clean closure standard of a clean debris surface. The concrete will be washed down; the rinsate collected, designated, and disposed of accordingly. The concrete will be reinspected for a clean debris surface. Concrete surfaces indicated by visual examination, as still being potentially contaminated will have the surface layer removed to a depth of 0.6 centimeter (0.25 inches) by scabbing or other approved methods. This will not threaten the environment, even if potential through-thickness cracks had been found during the inspection, because concrete decontamination (scabbing) will not employ liquid solutions that could enter cracks and because scabbing residues will be vacuumed away from cracks as, any residue is generated.

Achievement of a clean debris surface will be documented on an inspection record. Decontamination residues will be collected, designated, and managed as appropriate.

H.3.4.6 Structures

If contaminated with either dangerous or mixed waste constituents, the 200 Area ETF structures will be decontaminated and/or disassembled, if necessary, packaged, and disposed of in accordance with existing land disposal restrictions (WAC 173-303-140).

Closure steps could include the following activities.

- Containerize (as necessary and practicable) and remove any remaining waste.
- Review operating records for spillage incidents and visually inspect storage area surfaces for evidence of contamination or for cracks that could harbor contamination or allow the escape of decontamination solutions. Inspect storage area surfaces for visible evidence of contamination (e.g., discoloration, material degradation, wetness, and odor). If contamination is evident, the affected area(s) will be decontaminated.
- Decontaminate 200 Area ETF walls and floors to minimize the potential for loose contamination and facilitate any required surveys and/or chemical field screening. The structures could be cleaned by water rinse or high-pressure, low-volume steam cleaning coupled with a detergent wash. After decontamination, the walls and floors will be compared to closure performance standards.
- Collect rinsate and manage as dangerous waste for appropriate disposal.
- Secure (lock) personnel entries into building and post doors with appropriate warning signs.

H.3.4.7 Underlying Soils

Clean closure of soil under LERF's secondary liner will be accomplished by demonstrating that the liners and leak detection system kept contaminants from reaching the soil. The secondary liner provided secondary containment for the LERF basins. Unless inspections identify potential leaks, punctures, cracks, or tears indicating containment failure and a subsequent potential for soil contamination from TSD unit operations, the soil will be considered clean closed. However, if inspections identify such leaks, punctures, etc., potential soil contamination will be investigated.

Clean closure of soil under 200 Area ETF will be accomplished by demonstrating that the coated concrete floor kept contaminants from reaching the soil. The coated concrete floor and bermed area provided secondary containment for all the tanks and process piping. Unless inspections identify potential through-thickness cracks indicating containment failure and a subsequent potential for soil contamination from TSD unit operations, the soil will be considered clean closed. However, if inspections identify such cracks and there have been documented spills in the vicinity, potential soil contamination will be investigated.

Where it is possible visually to inspect directly beneath the tanks, a visual inspection will be performed. Where it is not possible visually to inspect beneath the tanks, an evaluation of the tank integrity will be made. The condition of the tank will be evaluated to determine if there was any potential for leakage. If no cracks, severe corrosion, or evidence of leaks is observed, it will be reasoned that mixed or dangerous waste solutions could not have penetrated to the soil directly below the tank.

External piping (transfer lines) between the 242-A Evaporator and LERF and 200 Area ETF are double lined with a leak detection system. If records indicate that no leaks from the primary piping occurred, the soil will be considered clean with respect to RCRA closure.

Where there is evidence that contamination may have leaked into the soil below tanks, concrete, or the soil/bentonite layer at LERF, the contaminated tank, concrete, or soil/bentonite layer will be removed to allow the underlying soil to be sampled to determine the depth of the contamination. Soil that is

contaminated above the closure performance standards in Section ~~G~~H.2.3 will be removed, placed in containers, and disposed accordingly.

H.4 Maximum Waste Inventory

The maximum waste inventory for LERF and 200 Area ETF is in Addendum A.

H.5 Closure of Containers, Tanks, and Surface Impoundments

The following sections cover closure of containers, closure of tanks, and closure of surface impoundments.

H.5.1 Closure of Containers

Containers at 200 Area ETF will be used to contain dangerous waste in the event of a spill, unexpected release, or equipment failure. Containers will be used to accumulate nonradioactive dangerous waste and/or mixed wastes. All containers will be emptied and treated prior to closure of 200 Area ETF. Any containers used to contain dangerous and/or mixed waste at the 200 Area ETF that is generated during the closure process and therefore cannot be treated at 200 Area ETF will be designated and shipped to an onsite TSD unit or off-site TSD facility. Containers of dangerous and/or mixed waste will not be left in the 200 Area ETF after closure.

H.5.2 Closure of Tanks

Clean closure of 200 Area ETF will consist of the removal and disposal of all dangerous waste and the decontamination and/or removal and disposal of equipment which does not meet the performance standards in Section ~~G~~H.2, including tanks. The 200 Area ETF was designed to incorporate removable components. This design facilitates closure by allowing complete removal of equipment, which does not meet the performance standards.

H.5.3 Closure of Surface Impoundments

At closure, all of LERF that received regulated waste will be closed in accordance with the requirements of this approved closure plan, which are intended to ensure compliance with the requirements of WAC 173-303-650(6)(a)(i). All equipment, structures, and other material associated with closure of LERF will be decontaminated or removed in accordance with WAC 173-303-610(2). All basin waste and decontamination rinsate will be transferred to 200 Area ETF. Sampling and testing will be conducted as described in Section ~~G~~H.3.4.2.

H.6 Schedule for Closure

Closure of LERF and 200 Area ETF is not anticipated to occur within the next 30 years. The actual year of closure will depend on the time required for current waste to be processed and what role the LERF and 200 Area ETF will play in processing additional waste generated during future activities in the 200 Areas. Other factors affecting the year of closure include changes in operational requirements, lifetime extension upgrades, and unforeseen factors. When a definite closure date is established, notification of closure will be provided in accordance with Permit Condition II.J.3~~1~~.

The activities required to complete closure are planned to be accomplished within 180 days in accordance with WAC 173-303-610(4)(b). Should a modified schedule be necessary, a revised schedule will be proposed through the permit modification procedure in accordance with WAC 173-303-610(4)(b).

ADDENDUM I
INSPECTION REQUIREMENTS

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ADDENDUM I
INSPECTION REQUIREMENTS

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I. INSPECTION REQUIREMENTS

I.1 Inspection Plan

This addendum describes the method and schedule for inspections of LERF and 200 Area ETF. The purpose of inspections is to help ensure that situations do not exist that might cause or lead to the release of dangerous and/or mixed waste that could pose a threat to human health and the environment. Abnormal conditions identified by an inspection will be corrected on a schedule that prevents hazards to workers, the public, and the environment.

I.1.1 General Inspection Requirements

The content and frequency of inspections are described in this section. Inspection records are retained in the Hanford Facility Operating Record, LERF and 200 Area ETF file, or other approved locations, in accordance with Permit Condition II.I.1.

In certain areas of the 200 Area ETF, many inspections are performed remotely to maintain ALARA exposure. Monitoring instruments are connected to audible alarms and visual indicators track alarm status. The monitoring system provides trending of selected monitoring data, graphics, and equipment summary displays.

A preventive maintenance recall system is employed to direct preventive maintenance activities at the LERF and 200 Area ETF. Equipment requiring maintenance is checked as indicated by the maintenance history and the manufacturer's recommendations. The preventive maintenance of certain equipment might not be possible if the LERF or the 200 Area ETF is in an operational mode. Thus, the preventive maintenance could be performed slightly earlier or later than planned to minimize impact on operations.

Instrumentation at 200 Area ETF is calibrated regularly to ensure accuracy and reliability. All process control instrumentation is calibrated on a schedule depending on previous calibration experience. An instrument calibration and recall system is employed to manage calibrations.

I.1.1.1 Types of Problems

Key components of the LERF inspection program include the following areas:

- Structural integrity of the basins
- Catch basin secondary containment system integrity
- Evidence of release from basins
- Safety, communications, and emergency equipment

Key components of the 200 Area ETF inspection program include the following areas:

- Condition of tanks and ancillary piping
- Condition of containers
- Condition of the process control equipment
- Condition of emergency equipment
- Condition of secondary containment

Table I.1 and Table I.2 provide a description of LERF and 200 Area ETF items to be inspected.

I.1.1.2 Frequency of Inspections

The frequency of inspections is based on the rate of possible deterioration of equipment and the probability of a threat to human health or the environment.

The LERF and 200 Area ETF is inspected as indicated in Table I.1 and Table I.2.

I.1.2 Specific Process Inspection Requirements

The following sections describe the specific process inspections performed at LERF and 200 Area ETF.

I.1.2.1 Container Inspections

Containers are used at the 200 Area ETF to store solidified secondary waste, such as the powder waste from the thin film dryer and maintenance and operations waste. When containers are being held in container storage areas, the following inspection schedule is maintained:

- Daily visual inspection of container storage area for leaks, spills, accumulated liquids, and open or improperly sealed containers
- Weekly visual inspection of container labels to ensure labels are not obscured, removed, or otherwise unreadable
- Weekly visual inspection for deterioration of containers, containment systems, or cracks in protective coating or foundations caused by corrosion, mishandling, or other factors.

Following the inspections, an inspection datasheet is signed and dated by the inspector and supervisor.

I.1.2.2 Tank Inspections

A description of the tank systems and ancillary equipment at the 200 Area ETF is given in Addendum C. Inspections and frequencies are given in Table I.1 and Table I.2. This section includes a brief discussion of the inspections.

I.1.2.2.1 Overfill Protection

Tanks that have the possibility of being overfilled have level instrumentation that alarms before the tanks reach overflow. High tank level alarms annunciate in the 200 Area ETF eControl rRoom, allowing operating personnel to take immediate action to stop the vessels from overfilling. These alarms are monitored continuously in the 200 Area ETF eControl rRoom during solution transfers. When tank level instrumentation is inoperable, the alternate controls discussed in Addendum C, Section C.4.4.2 are followed to prevent tank overfilling.

I.1.2.2.2 Visual Inspections

Visual inspections of tanks and secondary containments are performed to check for leaks, signs of corrosion or damage, and malfunctioning equipment. Inspections are performed on tanks, secondary containment within the 200 Area ETF, surge tank, and verification tank, and associated secondary containment.

I.1.2.2.3 Secondary Containment Leak Detectors

The surge tank and verification tank secondary containment systems have sloped floors that drain solutions to sumps equipped with leak detectors that alarm in the 200 Area ETF eControl rRoom. These alarms are monitored continuously in the 200 Area ETF eControl rRoom during 200 Area ETF processing operations or during waste transfers, and at least daily when processing operations or waste transfers are not occurring.at other times. If an alarm is activated, further investigation is performed to determine if the source is a tank leak or other solution (i.e., precipitation).

I.1.2.2.4 Integrity Assessments

The initial integrity assessment was issued in 1995 (Addendum C). Consistent with the recommendations of the integrity assessment, a periodic integrity assessment program was developed for the 200 Area ETF tanks and is discussed in detail in Addendum C, Section C.4.1.5C.4.2.

I.1.2.2.5 Effluent Treatment Facility Piping

The 200 Area ETF employs an extensive piping system. During inspections at the 200 Area ETF, any aboveground piping is inspected visually for signs of leakage and for general structural integrity. During the visual inspection, particular attention is paid to valves and fittings for signs of cracking, deformation, and leakage.

I.1.2.3 Surface Impoundments and Condition Assessment

The following describes the surface impoundment inspections performed at LERF.

I.1.2.3.1 Overtopping Control

Under current operating conditions, 0.61 ~~1.34~~ meters (2 feet) of freeboard is maintained at each LERF basin, which corresponds to an~~a normal~~ operating level of 6.8~~6.1~~ meters (22.2 feet), or operating capacity of 29.5~~24.6~~ million liters (7.8 million gallons). Level indicators at each basin are monitored to confirm that this level is not exceeded.

Before an aqueous waste is transferred into a basin, administrative controls are implemented to ensure overtopping will not occur during the transfer. The volume of feed to be transferred is compared to the available volume in the receiving basin. The transfer is not initiated unless there is sufficient volume available in the receiving basin or a cut-off level is established. The transfer into the basin would be stopped when this cut-off level is reached.

The LERF basins also are provided with floating very low-density polyethylene covers that are designed and constructed to prevent overtopping by the introduction of precipitation and dust into the basins. Overtopping and flow control also are discussed in Addendum C.

I.1.2.3.2 Impoundment Contents

The LERF basins are inspected weekly to assess whether the contents are escaping from a basin. Level indicators are inspected weekly to check for unaccountable change in the level of the basins.

I.1.2.3.3 Leak Detection

The leachate detection, collection, and removal system is described in Addendum C. The leachate collection sump pump is activated when the liquid level in the leachate sump reaches a preset level. A flow meter/totalizer measures the amount of leachate removed. In addition, the timer on the leachate pump tracks the cumulative pump run time. The leak rate through the primary liner can be determined using one of two methods

1) ~~1)~~ measured as the leachate flow meter/totalizer readings ~~or pump operating time readings~~ (flow meters/totalizers are located on the outflow line from the collection sumps in the bottom of the LERF basins) or

2) ~~2)~~ calculated using the pump operating time readings multiplied by the pump flow rate (the pump runs at a constant flow rate).

Calculations using either method are sufficient for compliance. If either the flow meter/ totalizer or pump operating time system is not functioning, this is identified as an abnormal condition (see Section I.1).

The LERF employs a double walled transfer piping between 242-A Evaporator and LERF and between LERF and 200 Area ETF. The WAC 173-303-650 regulations do not require a discussion of piping for surface impoundments. However, for the purposes of comprehensive coverage of the LERF, inspections and integrity assessments are performed on the piping system. Aqueous waste (e.g., process condensate) is transferred from the 242-A Evaporator to the LERF via a buried pipeline. Likewise, aqueous waste is transferred to the 200 Area ETF via buried pipelines. At the LERF dikes, aboveground piping serves to transfer waste from one basin to another.

The buried pipelines normally are continuously monitored during transfers by a leak detection system (Addendum C). Leak~~The alarms on the leak~~ detection system alarms annunciate~~signal~~ to the 200 Area ETF ~~c~~Control ~~r~~Room, which is monitored continuously during waste transfers and daily when no waste is transferring. ~~.~~ As an alternative to continuous leak detection, the transfer lines can be inspected daily during transfers by opening the secondary containment drain lines at the LERF catch basins (for 242-A Evaporator transfers to LERF) and the surge tank (for LERF transfers to 200 Area ETF) to inspect for leakage. During the routine inspections at LERF, the aboveground piping system is inspected for

signs of leakage and for general structural integrity. During the visual inspection, particular attention is paid to valves and fittings for signs of cracking, deformation, and leakage.

I.1.2.3.4 Dike Erosion

The LERF basins and dikes are visually inspected weekly and after significant precipitation events for run-on, run-off, cover integrity, erosion problems, or other signs of deterioration in the dikes from precipitation, wind, burrowing mammals, or vegetation.

I.1.2.3.5 Structural Integrity

A written certification attesting to the structural integrity of the basin dikes, signed by a qualified, registered professional engineer, is provided in Addendum C.

I.1.2.3.6 Container Inspection

Normal operation of the LERF does not involve the storage of dangerous waste in containers. Therefore, the inspection requirements of this section normally are not applicable to the LERF. Any containerized dangerous waste generated at LERF will be brought to the 200 Area ETF and managed in accordance with WAC 173-303-630 and is discussed in Addendum C~~in Section I.1.3~~.

I.1.3 Inspection Log

Observations made and deficiencies noted during an inspection are recorded on inspection log sheets (also called turnover sheets). On completion, the log sheet includes the inspector's printed name, signature, date, and time; the log sheet is submitted for review and approval by LERF and 200 Area ETF management or their designee, as required by operating procedures. Once approved, the log sheet is kept in the Hanford Facility Operating Record, LERF and 200 Area ETF files. Inspection records are retained in the Hanford Facility Operating Record, LERF and 200 Area ETF files, or other approved locations, in accordance with Permit Condition II.I.1. The inspection records are used to help determine any necessary corrective actions. Problems identified during the inspections are prioritized and addressed in a timely fashion to mitigate health risks to workers, maintain integrity of the TSD units, and prevent hazards to public health and the environment.

If while performing an inspection, a leak or spill is discovered, facility operations responds per the emergency response procedures action is taken to stop the leak and determine the cause. The waste is removed from the secondary containment in a timely manner that prevents harm to human health and the environment.

I.1.4 Storage of Ignitable or Reactive Wastes

The LERF could receive an aqueous waste that is designated reactive or ignitable. Any aqueous waste exhibiting these characteristics is managed (e.g., through blending in LERF) such that the waste no longer exhibits the reactive or ignitable characteristics.

Though unlikely, the 200 Area ETF secondary wastes might have the characteristics of being reactive or ignitable. A qualified inspector performs annual fire inspections of the 200 Area ETF using a checklist developed specifically for facilities that handle dangerous and/or mixed waste.

~~Table I.1. Visual Inspection Schedule for the LERF and 200 Area ETF~~

TABLE I.1. VISUAL INSPECTION SCHEDULE FOR THE LERF AND 200 AREA ETF

ITEM	INSPECTION	FREQUENCY
	2025-ED Load-In Station~~Facility~~	
Load-In Station tank system	Inspect area for leaks. Note any unusual noises or vibration from the system pumps. Inspect secondary containment system for signs of deterioration.	Daily
	Main Treatment Train	
Surge tank system	Inspect area for leaks. Note any unusual noises or vibration from the system pumps. Inspect secondary containment system for signs of deterioration.	Daily
Rough filter	Inspect for leaks.	Daily
Ultraviolet oxidation system	Inspect module for leaks Inspect peroxide storage tank, ancillary equipment for leaks.	Daily
pH adjustment tank	Inspect tank and ancillary equipment for leaks	Daily
H_2O_2 decomposer	Inspect tank and ancillary equipment for leaks	Daily
Fine filter	Inspect module for leaks	Daily
Degasification system	Inspect module for leaks. Note any unusual noises or vibration from the degasification blower.	Daily
Reverse osmosis system	Inspect tanks and ancillary equipment for leaks. Note any unusual noises or vibration from the system pumps.	Daily
Polishers	Inspect tanks and ancillary equipment for leaks.	Daily
Effluent pH adjustment tank	Inspect tank and ancillary equipment for leaks.	Daily
Verification tanks	Inspect tanks and ancillary equipment for leaks. Note any unusual noises or vibration from the system pumps. Inspect secondary containment system for signs of deterioration.	Daily
	Secondary Treatment Train	
Secondary waste receiving tank	Inspect tank and ancillary equipment for leaks	Daily
200 Area ETF evaporator	Inspect tank and equipment for leaks. Note any unusual noises or vibration from the system pumps or compressor.	Daily
Concentrate tank	Inspect tank and ancillary equipment for leaks.	Daily
Thin ~~f~~Film ~~d~~Dryer Room	Inspect piping~~tanks~~ and ancillary equipment for spills, leaks, and accumulated liquids (viewed through camera). Note any unusual noises or vibration from the system pumps or blower.	Daily[1]
Container handling	Inspect area for spills, leaks, accumulated liquids.	Daily
Container handling	Inspect for deterioration of containers and secondary containment, including corrosion and cracks in secondary containment foundation and coating. Inspect container labels to ensure that they are readable.	Weekly
	Support Systems	
Vessel ventilation system	Inspect filters (HEPA and pre-filters), check vessel off gas pressures, system flow, and discharge temperatures.	Daily
Sump tank system	Inspect sump trenches for unexpected liquids, which indicate spills or leaks from process equipment.	Daily
	Safety Systems	
Eye wash stations	Check status; check for adequate pressure	Monthly
Safety showers	Check status; check for adequate pressure	Monthly
	Emergency Systems	
Fire extinguishers	Check for adequate charge.	Monthly
Emergency lighting	Test operability.	Monthly

[1] If the camera system is inoperable, daily visual inspections will be performed or the Thin Film Dryer will be emptied and isolated as described in Addendum C, Section C.4.4.2, to prevent waste additions that could result in undetected leaks or spills in the Thin Film Dryer Room.

TABLE I.1. VISUAL INSPECTION SCHEDULE FOR THE LERF AND 200 AREA ETF

ITEM	INSPECTION	FREQUENCY
	Processing Area	
Uninterruptible power supply	Check output voltage and visually inspect battery pack for corrosion and leakage. Check indicator lights for fault conditions.	Annually
	LERF (Surface Impoundment)	
LERF basins and dikes	Check the~~to~~ overtopping controls and integrity of the basins and dikes	Weekly
LERF contents	Check basin level indicators for unaccountable changes in the level of the basins	Weekly
Leak Detections	Determine the leak rate per wetted surface area	Weekly
LERF basins and dikes	Check for run-on, run-off, cover integrity, erosion problems, and other signs of deterioration	Weekly & After significant precipitation events
	Ignitable and Reactive	
Ignitable and reactive waste	Storage in compliance with Hanford Site fire protection standards and WAC 173-303-630(8)	Annually[2]~~‡~~
	Container Storage Areas Other Than Secondary Treatment Train	
Container Storage	Container labels to ensure labels are not obscured, removed, or otherwise unreadable	Weekly
	Deterioration of containers, containment systems, or cracks in protective coating or foundations caused by corrosion, mishandling, or other factors	Weekly
	Leaks, spills, ~~and~~ accumulated liquids, and open or improperly sealed containers	Daily

HEPA – High efficiency particulate air

~~‡~~[2] When waste management activities occur

I.1.5 Instrumentation Monitoring

Continuous monitoring applies to the electronic monitoring performed in the 200 Area ETF Control Room for this instrumentation during 200 Area ETF processing operations and/or 2025-E Load-In Station transfers. Data from alarms, leak detectors, and level transmitters are monitored daily in the 200 Area ETF Control Room when waste transfers are not occurring (see C.2.5.1). In cases where this instrumentation is out of service (e.g., calibration, power failures, or maintenance) daily visual inspections will be performed in accordance with WAC 173-303-640, using the alternate methods discussed in Addendum C, Section C.1 for leak detection, Section C.4.3.1.2 for level inspection, and Section C.4.4.2 for overfill prevention will be followed.

In the event the electronic leak detectors or level indicators for Sump Tank 1 or Sump Tank 2 are out of service, daily visual inspections will be performed each operating day (WAC-173-303-640).

Inspections pertaining to instrumentation monitoring is provided in Table I.2.

Table I.2. Inspection Plan for Instrumentation Monitoring

ITEM	INSPECTION	FREQUENCY *
	2025-ED Load-In StationFacility	
Level alarm LAHH-59A-109/-117	Monitor liquid level in lLoad-iIn tTanks TK-109 and TK-117 to prevent overflow	Continuously
Level alarm LSH-59A-003	Monitor liquid level in lLoad-iIn tTanks TK-1 to prevent overflow	Continuously
Leak detector	Monitor for leakage in the lLoad-iIn Station tank pit sump	Continuously
	Main Treatment Train	
Leak detector LAH-20B009	Monitor for leakage in the surge tank drainage sump	Continuously
Level alarm LAH-60A013	Monitor surge tank level to prevent overflow	Continuously
Level alarm LAHL-60C-111	Monitor liquid levels in the pH adjustment tank to prevent overflow	Continuously
Level alarm LAHL-60F-101	Monitor liquid levels in the first RO feed tank to prevent overflow	Continuously
Level alarm LAHL-60F-201	Monitor liquid levels in the second RO feed tank to prevent overflow	Continuously
Level alarms LAHL-60CF-211	Monitor liquid levels in the effluent pH adjustment tank to prevent overflow	Continuously
Level transmitter LAHX-60H001A/B/C	Monitor liquid level in verification tanks to prevent overflow	Continuously
Leak detector LAH-20B010	Monitor for leakage in the verification tank drainage sump	Continuously
	Secondary Treatment Train	
Level alarm LAHL-60I-001A/B	Monitor liquid levels in secondary waste receiver tanks A and B to prevent overflow.	Continuously
Level alarm LAHL-60J-001A/B	Monitor liquid levels in concentrate tanks A and B to prevent overflow.	Continuously
Level alarm LAHL-60I-107	Monitor liquid levels in the evaporator tank to prevent overflow.	Continuously
Level alarm LAHL-60J-036	Monitor liquid levels in the spray condenser tank to prevent overflow.	Continuously
Level alarm LAHL-60I-108	Monitor liquid levels in the distillate flash tank to prevent overflow.	Continuously
Level alarm LAH-60I-119	Monitor liquid levels in the entrainment separator tank to prevent overflow.	Continuously
Level transmitter LAH-20B001	Monitor liquid level in Sump Tanksump tank No. 1 to prevent overflow.	Continuously
Level transmitter LAH-20B002	Monitor liquid level in Sump Tanksump tank No. 2 to prevent overflow.	Continuously
Leak detector LAH-20B003	Monitor for leakage to Ssump No. 1.	Continuously**
Leak detector LAH-20B005	Monitor for leakage to Ssump No. 2.	Continuously**
Leak detector	Monitor for leakage from pipeline between 200 Area ETF and 2025-ED Load-In Stationload in station.	Continuously**
Leak detector	Monitor for leakage from pipeline between 200 Area ETF and LERF.	Continuously**
Leak detector	Monitor for leakage from pipeline between LERF and the 242-A Evaporator.	Continuously**

~~* Frequency of "continuously" applies during ETF processing operations and/or Load-in Station transfers. Data from alarms, leak detectors, and level transmitters is monitored in the control room at least daily at other times, even though many of these instruments record continuously (see C.2.5.1). Emergency communications equipment and warning systems (e.g. fire alarms, take cover alarms, and evacuation alarms) are included in addendum J, Contingency Plan. These alarms are monitored continuously and the response to these alarms do not rely on personnel being present the ETF control room.~~

~~** In the event of a malfunction of one of the electronic leak detectors, daily visual inspections will be performed while the facilities are in operation.~~

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ADDENDUM J
CONTINGENCY PLAN

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ADDENDUM J
CONTINGENCY PLAN

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J. CONTINGENCY PLAN

The requirements for a contingency plan at LERF/ and 200 Area ETF are satisfied in the following documents: portions of Hanford Facility Permit (Permit) Attachment 4, *Hanford Emergency Management Plan* (DOE/RL-94-02) and this Addendum.

The unit specific building emergency plan also serves to satisfy a broad range of other requirements [e.g., Occupational Safety and Health Administration standards (29 CFR 1910), *Toxic Substance Control Act of 1976* (40 CFR 761) and U.S. Department of Energy Orders]. Therefore, revisions made to portions of this unit specific building emergency plan that are not governed by the requirements of WAC 173-303 will not be considered as a modification subject to WAC 173-303-830 or Permit Condition I.C.3.

Table J.1 identifies the sections of the unit specific building emergency plan written to meet WAC 173-303-350(3) contingency plan requirements. In addition, Section 12.0 of the unit specific building emergency plan is written to meet WAC 173-303 requirements identifying where copies of Permit Attachment 4, *Hanford Emergency Management Plan* (DOE/RL-94-02) and the building emergency plan are located and maintained on the Hanford Facility. Therefore, revisions to Addendum J require a modification subject to WAC 173-303-830 and/or Permit Condition I.C.3.

Table J.1. Hanford Facility Documents Containing Contingency Plan Requirements of WAC 173-303-350(3)

Requirement	Permit Attachement 4, Hanford Emergency Management Plan (DOE/RL-94-02)	Building Emergency Plan[1] (HNF-IP-0263-ETF)	Part III, OU-3, LERF & 200 Area ETF, Addendum J
-350(3)(a) - A description of the actions, which facility personnel must take to comply with this section and WAC 173-303-360.	X[2] Section 1.3.4	X[2] Sections 7.1, 7.2 through 7.2.5, and 7.3[3] Sections 4.0 (1st paragraph), 8.2, 8.3, 8.4, 11.0	X[2] Sections J.3.1, J.3.2, through J.3.2.5, and J.3.3[3] Sections J.3, J.3.4, J.3.5, J.3.6, and J.5
-350(3)(b) - A description of the actions which shall be taken in the event that a dangerous waste shipment, which is damaged or otherwise presents a hazard to the public health and the environment, arrives at the facility, and is not acceptable to the owner or operator, but cannot be transported pursuant to the requirements of WAC 173-303-370(5), Manifest system, reasons for not accepting dangerous waste shipments.	X[2] Section 1.3.4	X[2, 4] Section 7.2.5.1	X[2,4] Section J.3.2.5.1
-350(3)(c) - A description of the arrangements agreed to by local police departments, fire departments, hospitals, contractors, and state and local emergency response teams to coordinate emergency services as required in WAC 173-303-340(4).	X Sections 3.2.3, 3.3.1, 3.3.2, 3.4, 3.4.1.1, 3.4.1.2, 3.4.1.3, 3.7, and Table 3-1		

Table J.1. Hanford Facility Documents Containing Contingency Plan Requirements of WAC 173-303-350(3)

Requirement	Permit Attachement 4, Hanford Emergency Management Plan (DOE/RL-94-02)	Building Emergency Plan[1] (HNF-IP-0263-ETF)	Part III, OU-3, LERF & 200 Area ETF, Addendum J
-350(3)(d) - A current list of names, addresses, and phone numbers (office and home) of all persons qualified to act as the emergency coordinator required under WAC 173-303-360(1). Where more than one person is listed, one must be named as primary emergency coordinator, and others must be listed in the order in which they will assume responsibility as alternates. For new facilities only, this list may be provided to the department at the time of facility certification (as required by WAC 173-303-810(14)(a)(I)), rather than as part of the permit application.		X[5] Section 3.1, 13.0	X[5] Sections J.2 and J.7
-350(3)(e) - A list of all emergency equipment at the facility (such as fire extinguishing systems, spill control equipment, communications and alarm systems, and decontamination equipment), where this equipment is required. This list must be kept up to date. In addition, the plan must include the location and a physical description of each item on the list, and a brief outline of its capabilities.		X Section 9.0	X Section J.4
-350(3)(f) - An evacuation plan for facility personnel where there is a possibility that evacuation could be necessary. This plan must describe the signal(s) to be used to begin evacuation, evacuation routes, and alternate evacuation routes.	X[6] Figure 7-3 and Table 5-1	X[7] Section 1.5	X[7] Section J.1

An "X" indicates requirement applies.

[1] Portions of Permit Attachment 4, *Hanford Emergency Management Plan* (DOE/RL-94-02) not enforceable through Appendix A of that document are not made enforceable by reference in the building emergency plan.

[2]Permit Attachment 4, H*anford Emergency Management Plan* (DOE/RL-94-02) contains descriptions of actions relating to the Hanford Site Emergency Preparedness System. No additional description of actions are required if at the site level. If other credible scenarios exist or if emergency procedures at the unit are different, the description of actions contained in the building emergency plan will be used during an event by a building emergency director.

[3]Sections J.1, J.2 through J.2.5, and J.3 of the building emergency plan are those sections subject to the Class 2 "Changes in emergency procedures (i.e., spill or release response procedures)" described in WAC 173-303-830, Appendix I, Section B.6.a.

[4]This requirement only applies to TSD units, which receive shipment of dangerous or mixed waste defined as off-site shipments in accordance with WAC 173-303.

[5]Emergency Coordinator names and home telephone numbers are maintained separate from any contingency plan document, on file in accordance with Permit Condition II.A.4 and are updated, at a minimum, monthly.

[6]The Hanford Facility (site wide) signals are provided in this document. No unit/building signal information is required unless unique devices are used at the unit/building.

[7]An evacuation route for the TSD unit must be provided. Evacuation routes for occupied buildings surrounding the TSD unit are provided through information boards posted within buildings.

J.1 Building Evacuation Routing

Figures J.1 and J.2 provide identification of the primary and secondary staging areas and a general layout of the building 2025-E and ~~ETF/~~LERF, and 200 Area ETF. Alternate evacuation routes will be used on a case-by-case basis based on meteorological conditions at the time of the event.

J.2 Building Emergency Director

Emergency response will be directed by the Building Emergency Director (BED) until the Incident Commander (IC) arrives. The Incident Command System and staff with supporting on-call personnel fulfill the responsibilities of the Emergency Coordinator as discussed in WAC 173-303-360.

During events, LERF and 200 Area ETF~~/LERF~~ personnel perform response duties under the direction of the BED. The Incident Command Post (ICP) is managed by the senior Hanford Fire Department official, unless the event is determined to be primarily a security event, in which case the Hanford Fire Department and Hanford Patrol will operate under a unified command system with Hanford Patrol making all decisions pertaining to security. These individuals are designated as the IC and as such, have the authority to request and obtain any resources necessary for protecting people and the environment. The BED becomes a member of the ICP and functions under the direction of the IC. In this role, the BED continues to manage and direct LERF/ and 200 Area ETF operations.

A listing of BEDs by title, work location, and work telephone numbers is contained in Section J.7 of this plan. The BED is on the premises or is available through an "on-call" list 24 hours a day. Names and home telephone numbers of the BEDs are available from the Patrol Operations Center (POC) in accordance with Permit Condition II.A.4.

J.3 Implementation of the Plan

In accordance with WAC 173-303-360(2)(b) the BED ensures that trained personnel identify the character, source, amount, and areal extent of the release, fire, or explosion to the extent possible. Identification of waste can be made by activities that can include, but are not limited to, visual inspection of involved containers, sampling activities in the field, reference to inventory records, or by consulting with facility personnel. Samples of materials involved in an emergency might be taken by qualified personnel and analyzed as appropriate. These activities must be performed with a sense of immediacy and shall include available information.

The BED shall use the following guidelines to determine if an event has met the requirements of WAC 173-303-360(2)(d):

1. The event involved an unplanned spill, release, fire, or explosion,

AND

2.a The unplanned spill or release involved a dangerous waste, or the material involved became a dangerous waste as a result of the event (e.g., product that is not recoverable.), or

2.b The unplanned fire or explosion occurred at the ~~ETF/~~LERF and 200 Area ETF or transportation activity subject to RCRA contingency planning requirements,

AND

3. Time urgent response from an emergency services organization was required to mitigate the event or a threat to human health or the environment exists.

As soon as possible, after stabilizing event conditions, the BED shall determine, in consultation with the site contractor environmental single point-of-contact, if notification to the Washington State Department of Ecology (Ecology) is needed to meet WAC 173-303-360(2)(d) reporting requirements. If all of the conditions under 1, 2, and 3 are met, notifications are to be made to Ecology. Additional information is found in Permit Attachment 4, *Hanford Emergency Management Plan*, (DOE/RL-94-02), Section 4.2.

If review of all available information does not yield a definitive assessment of the danger posed by the incident, a worst-case condition will be presumed and appropriate protective actions and notifications will

be initiated. The BED is responsible for initiating any protective actions based on their best judgment of the incident.

The BED must assess each incident to determine the response necessary to protect the personnel, facility, and the environment. If assistance from Hanford Patrol, Hanford Fire Department, or ambulance units is required, the Hanford Emergency Response Number (911 from site office phones/373-0911 from cellular phones) must be used to contact the POC and request the desired assistance. To request other resources or assistance from outside the ~~ETF/~~LERF and 200 Area ETF, the POC business number is 373-3800.

J.3.1 Protective Actions Responses

Protective action responses are discussed in the following sections. The steps identified in the following description of actions do not have to be performed in sequence because of the unanticipated sequence of incident events.

J.3.1.1 Evacuation

The objective of a facility evacuation order is to limit personnel exposure to hazardous materials or dangerous/mixed waste by increasing the distance between personnel and the hazard. The scope of the evacuation includes evacuation of the facility because of an event at the facility as well as evacuation of the facility in response to a site evacuation order. Evacuation will be directed by the BED when conditions warrant and will apply to all personnel not actively involved in the event response or emergency plan related activities.

The BED will initiate the evacuation by directing an announcement be made to evacuate along with the evacuation location over a public address system, facility radios, and, as conditions warrant, by activating the 200 Area site evacuation alarms by calling the POC using 911 from site office phones/373-0911 from cellular phones. Personnel proceed to a predetermined staging area (shown in Figure J.2), or other safe upwind location, as determined by the BED. The BED will determine the operating configuration of the facility and identify any additional protective actions to limit personnel exposure to the hazard.

Emergency organization personnel or assigned operations personnel will conduct a sweep of occupied buildings to ensure that all non-essential personnel and visitors have evacuated. For an immediate evacuation, accountability will be performed at the staging area. The BED will assign personnel as accountability aides and staging managers with the responsibility to ensure that evacuation actions are taken at all occupied buildings at the ~~ETF/~~LERF~~,~~ and 200 Area ETF. All implementing actions executed by the aides/managers are directed by the emergency response procedures. When evacuation actions are complete, the aides/managers will provide a status report to the BED. The BED will provide status to the IC.

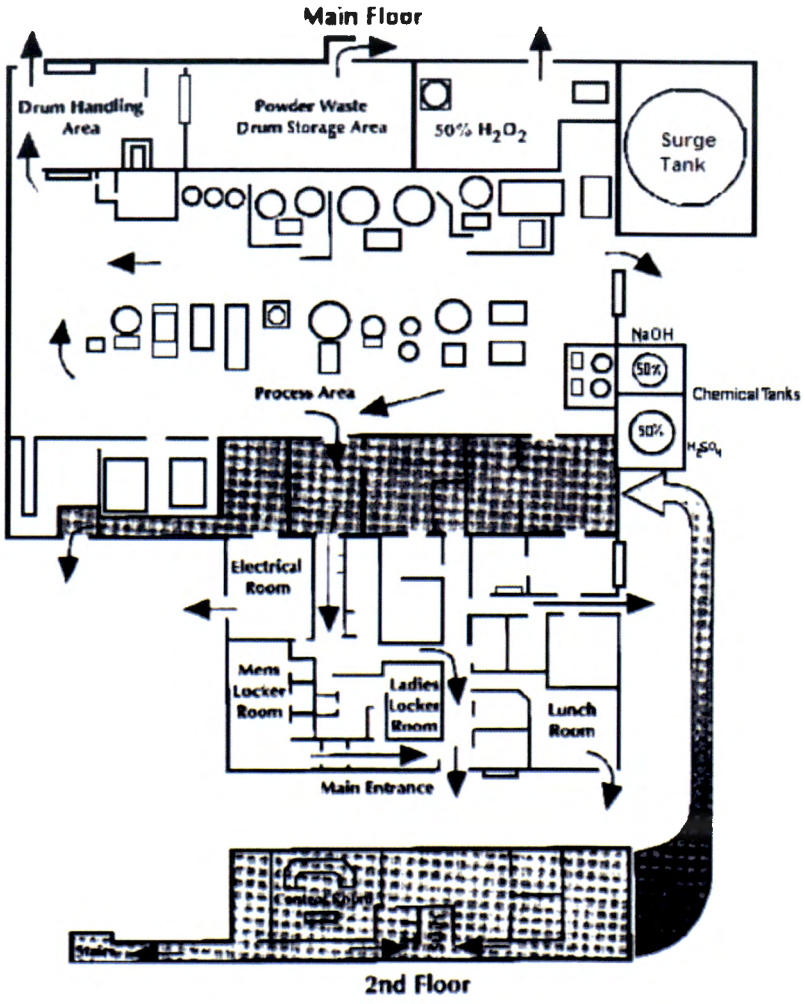

Figure J.1. Evacuation Routes from Building 2025-E

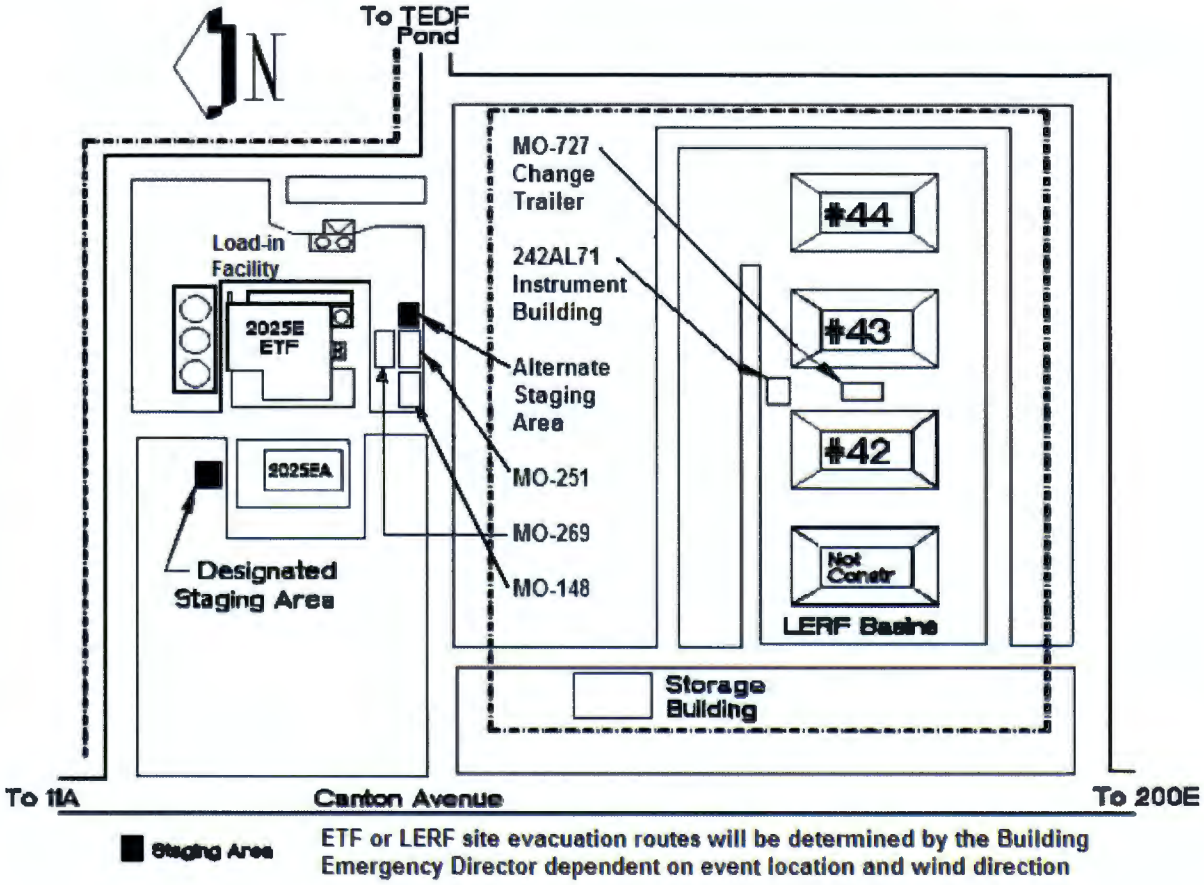

Figure J.2. LERF and 200 Area ETF Site Plan

J.3.1.2 Take Cover

The objective of the take cover order is to limit personnel exposure to hazardous materials, or dangerous/mixed waste when evacuation is inappropriate or not practical. Evacuation might not be practical or appropriate because of extreme weather conditions or the material release might limit the ability to evacuate safely personnel.

The BED will initiate the take cover by directing an announcement be made over the public address system, facility radios, and, as conditions warrant, by activating the 200 Area site take cover alarms by calling the POC using 911 from site office phones/373-0911 from cellular phones). Actions to complete a facility take-cover will be directed by the emergency response procedure. Protective actions associated with operations include configuring, or shutting down, the ventilation systems. Determination of additional take cover response is based on plant operating configuration, weather conditions, amount and duration of release, and other conditions, as applicable to the event and associated hazard. As a minimum, personnel exposure to the hazard will be minimized. The BED will assign personnel as accountability aides with responsibility to ensure that take-cover actions are taken at all occupied buildings at ~~the~~200 Area ETF ~~complex~~. All implementing actions executed by the aides/managers are directed by the emergency response procedure. When take cover actions are complete, the aides/manager will provide the BED with a status report.

J.3.2 Response to Facility Operations Emergencies

Depending on the severity of the following events, the BED reviews the site wide procedures and ~~ETF/~~LERF and 200 Area ETF emergency response procedure(s) and, as required, categorizes and/or classifies the event. If necessary, the BED initiates area protective actions and Hanford Site Emergency Response Organization activation. The steps identified in the following description of actions do not have to be performed in sequence because of the unanticipated sequence of incident events.

J.3.2.1 Loss of Utilities

A case-by-case evaluation is required for each event to determine loss of utility impacts. When a BED determines a loss of utility impact, actions are taken to ensure dangerous and/or mixed waste is being properly managed, to the extent possible given event circumstances. As necessary, the BED will stop operations and take appropriate actions until the utility is restored.

J.3.2.2 Major Process Disruption/Loss of Plant Control

The hazards assessment has determined that this occurrence does not pose significant risk to human health or the environment.

J.3.2.3 Pressure Release

The hazards assessment has determined that a pressure release does not pose significant risk to human health or the environment. Hazardous material release and dangerous/mixed waste releases are addressed in Section J.2.5.

J.3.2.4 Fire and/or Explosion

In the event, of a fire, the discoverer activates a fire alarm (pull box); calls 911 from site office phones/373-0911 from cellular phones or verifies that the Hanford Emergency Response Number has been called. Automatic initiation of a fire alarm (through the smoke detectors, and sprinkler systems) is also possible.

- Unless otherwise instructed, personnel shall evacuate the area/building by the nearest safe exit and proceed to the designated staging area for accountability.
- On actuation of the fire alarm, ONLY if time permits, personnel should shut down equipment, secure waste, and lock up classified materials (or hand carry them out). The alarm automatically signals the Hanford Fire Department.

- The BED proceeds directly to the ICP, obtains all necessary information pertaining to the incident, and sends a representative to meet Hanford Fire Department.
- The BED provides a formal turnover to the IC when the IC arrives at the ICP.
- The BED informs the Hanford Site Emergency Response Organization as to the extent of the emergency (including estimates of dangerous waste and mixed waste quantities released to the environment).
- If operations are stopped in response to the fire, the BED ensures that systems are monitored for leaks, pressure buildup, gas generation, and ruptures.
- Hanford Fire Department firefighters extinguish the fire as necessary.

NOTE: Following a fire and/or explosion, WAC 173-303-640(7) will be addressed for the 200 Area ETF regarding fitness for use.

J.3.2.5 Hazardous Material, Dangerous and/or Mixed Waste Spill

Spills can result from many sources including process leaks, container spills or leaks, damaged packages or shipments, or personnel error. Spills of mixed waste are complicated by the need to deal with the extra hazards posed by the presence of *Atomic Energy Act* materials. These controls include containment berms, dedicated spill control sumps, remote gauges, and level indicators as well as spray shields on chemical pipe flanges. WRPS procedures provide alarm response and maintenance actions for leak detection equipment, surveillance of possible leak locations, and response actions for detected spills.

- The discoverer notifies BED and initiates SWIM~~S~~ response:

  Stops work
  Warns others in the vicinity
  Isolates the area
  Minimizes the exposure to the hazards
  ~~Requests the BED Secure ventilation~~

- If Operations are stopped, the BED ensures that the plant is put in a safe shutdown configuration.
- The BED determines if emergency conditions exist requiring response from the Hanford Fire Department based on classification of the spill and injured personnel, and evaluates need to perform additional protective actions.
- If the Hanford Fire Department resources are not needed, the spill is mitigated with resources identified in Section J.4 of this plan and proper notifications are made.
- If the Hanford Fire Department resources are needed, the BED calls 911 from site office phones/373-0911 from cellular phones.
- The BED sends a representative to meet the Hanford Fire Department.
- The BED provides a formal turnover to the IC when the IC arrives at the ICP.
- The BED informs the Hanford Site Emergency Response Organization as to the extent of the emergency (including estimates of dangerous waste and mixed waste quantities released to the environment).
- If operations are stopped in response to the spill, the BED ensures that systems are monitored for leaks, pressure buildup, gas generation, and ruptures.
- Hanford Fire Department stabilizes the spill.

NOTE: For response to leaks or spills and disposition of leaking or unfit-for-use tank systems, refer to WAC 173-303-640(7).

J.3.2.5.1 Damaged, or Unacceptable Shipments

During the course of receiving an onsite transfer of dangerous and/or mixed waste at ~~ETF/~~LERF and 200 Area ETF an unanticipated event could be discovered resulting in a conformance issue concerning the waste. Damaged or unacceptable shipments resulting from onsite transfers are not subject to WAC 173--303--370 however conformance issues must be resolved in order to maintain proper records.

The following actions are taken to resolve the conformance issue:

- Operations management is notified of the damaged or unacceptable waste to be received.
- If the conformance issue results in a spill or release, actions described in Section J.3.2.5 are taken.
- The generating organization is notified of the conformance issue.

An operations representative, in conjunction with the generating organization, determines the course of action to resolve the conformance issue.

J.3.3 Prevention of Recurrence or Spread of Fires, Explosions, or Releases

The BED, as part of the ICP, takes the steps necessary to ensure that a secondary release, fire, or explosion does not occur. The BED will take measures, where applicable, to stop processes and operations, collect and contain released waste, and remove or isolate containers. The BED also monitors for leaks, pressure buildups, gas generation, or ruptures in valves, pipes, or other equipment, whenever this is appropriate.

J.3.4 Incident Recovery and Restart of Operations

A recovery plan is developed when necessary in accordance with Permit Attachment 4, *Hanford Emergency Management Plan*, (DOE/RL-94-02), Section 9.2. A recovery plan is needed following an event where further risk could be introduced to personnel, the ~~ETF/~~LERF and 200 Area ETF, or the environment through recovery action and/or to maximize the preservation of evidence.

If this plan was implemented according to Section J.3 of this plan, Ecology is notified before operations can resume. The Permit Attachment 4, *Hanford Emergency Management Plan*, (DOE/RL-94-02), Section 5.1 discusses different reports to outside agencies. This notification is in addition to those required reports and includes the following statements:

- There are no incompatibility issues with the waste and released materials from the incident.
- All the equipment has been cleaned, fit for its intended use, and placed back into service.

The notification required by WAC 173-303-360(2)(j) may be made via telephone conference. Additional information that Ecology requests regarding these restart conditions will be included in the required 15-day report identified in Section J.5 of this plan.

For emergencies not involving activation of the Hanford EOC, the BED ensures that conditions are restored to normal before operations are resumed. If the Hanford Site Emergency Response Organization was activated and the emergency phase is complete, a special recovery organization could be appointed at the discretion of RL to restore conditions to normal. This process is detailed in RL and contractor emergency procedures. The makeup of this organization depends on the extent of the damage and the effects. The onsite recovery organization will be appointed by the appropriate contractor's management.

J.3.5 Incompatible Waste

After an event, the BED or the onsite recovery organization ensures that no waste that might be incompatible with the released material is treated, stored, and/or disposed of until cleanup is completed. Cleanup actions are taken by ~~ETF/~~LERF and 200 Area ETF personnel or other assigned personnel. Permit Attachment 4, *Hanford Emergency Management Plan*, (DOE/RL-94-02), Section 9.2.3, describes actions to be taken.

Waste from cleanup activities is designated and managed as newly generated waste. A field check for compatibility before storage is performed as necessary. Incompatible wastes are not placed in the same container. Containers of waste are placed in storage areas appropriate for their compatibility class.

If incompatibility of wastes was a factor in the incident, the BED or the onsite recovery organization ensures that the cause is corrected.

J.3.6 Post Emergency Equipment Maintenance and Decontamination

All equipment used during an incident is decontaminated (if practicable) or disposed of as spill debris. Decontaminated equipment is checked for proper operation before storage for subsequent use. Consumable and disposed materials are restocked. Fire extinguishers are replaced.

The BED ensures that all equipment is cleaned and fit for its intended use before operations are resumed. Depleted stocks of neutralizing and absorbing materials are replenished; protective clothing is cleaned or disposed of and restocked, etc.

J.4 Emergency Equipment

Emergency resources and equipment for the ~~ETF/~~LERF and 200 Area ETF are presented in this section.

J.4.1 Fixed Emergency Equipment

TYPE	LOCATION	CAPABILITY
Safety shower/ eye wash stations (200 Area ETF only)	• 2025-E Rm 112 Laboratory • ~~1~~—2025-E Rm 122 Decon Station ~~1 - 2025E South Wall of Process Area~~ • ~~1~~—2025-E Rm 131, South Process Area • ~~1~~—2025-E Rm 134, Air Compressor Room ~~1 - Outside south~~ 2025-E ~~near~~Concentrated acid/ caustic tanks area (outside) • ~~1 - Outside at~~2025-ED Load-iIn sStation (outside) • ~~1 - 2025E Rm 112 Laboratory~~	Assist in flushing chemicals/ materials from the body and/ or eyes and face of personnel.
Wet pipe sprinkler (200 Area ETF only)	Throughout ~~the ETF~~building 2025-E except those areas protected by preactive sprinklers	Assist in the control of a fire.
Preactive sprinkler (200 Area ETF only)	200 Area ETF Control ~~r~~Room, communications room, electrical equipment room	Assist in the control of a fire. Maintained dry to prevent accidental damage to equipment
Fire alarm pull boxes (200 Area ETF only)	All high traffic areas in operations administration and support areas, truck bay, and process area	Activate the local fire alarm
E-lights	Throughout 200 Area ETF	1 hour temporary lighting

J.4.2 Portable Emergency Equipment

TYPE	LOCATION	CAPABILITY
Fire extinguisher ABC type	Throughout 200 Area ETF (Administrative/Support areas), LERF, and TEDF	Fire suppression for Class A, B, and C fires
Fire extinguisher BC type	Throughout 200 Area ETF (process area and electrical room)	Fire suppression for Class B and C fires
Portable safety showers and Eye Wash Stations	As needed for special evolutions and maintenance	Assist in flushing chemicals/ materials from the body and/or eyes and face of personnel.

J.4.3 Communications Equipment/Warning Systems

TYPE	LOCATION	CAPABILITY
Fire alarms (200 Area ETF only)	Corridors, locker rooms, process area, drum storage, and truck bay	Audible throughout 200 Area ETF
Take cover/evacuation	Throughout the 200 Area ETF	Audible outside buildings and inside administrative buildings
Public address system (200 Area ETF Only)	Throughout the 200 Area ETF	Audible throughout 200 Area ETF
Portable radios	Operations and maintenance personnel	Communication to ~~control room~~200 Area ETF Control Room
Telephone	• **200 Area ETF~~ control room~~:** Control Room, 2025-E, 2025-EA offices, MO-148, MO-269, MO-251, ~~2025EC71.~~2025-EC-71 • **LERF~~:~~** MO-727 and 242AL71 instrument building, LERF Garage 242AL11 • **TEDF~~:~~** 225-E (pump house 1), 225W (pump house 2), 6653 (sample building), 6653-A (pump house 3)	Internal and external communications. Allows notification of outside resources (POC, HFD, Hanford Patrol, etc.

Note: Sitewide communications and warning systems are identified in Permit Attachment 4, *Hanford Emergency Management Plan*, (DOE/RL-94-02), Table 5.1.

J.4.4 Personal Protective Equipment

TYPE	LOCATION	CAPABILITY
Acid suits	In the spill response cabinets in 2025-E	Chemical protection for personnel during containment and isolation
Respirators	2025-E, 1st Floor	Filtered air for recovery of known hazards

J.4.5 Spill Control and Containment Supplies

~~SPILL KITS AND SPILL CONTROL EQUIPMENT~~		
TYPE	**LOCATION**	**CAPABILITY**
Spill bags, drums, carts, etc.	• ~~4~~ 2025-E in process area ~~1 TEDF 6653 Disposal Building~~ • ~~1~~ 2025-E upper level process area • ~~1~~ 2025-E Rm 125A • ~~1~~ 2025-ED Load-In Station ~~CONEX~~ • TEDF 6653 Disposal Building	Support containment and cleanup of hazardous material spills
Spill response cabinet	• ~~1~~ 2025-E Rm 122 • ~~2~~ container storage CONEX East of 2025E building within the TSD unit boundary • ~~1~~ outside southeast side of 2025E • ~~1~~ TEDF 6653 Disposal Building ~~1~~ MO-727 Change Trailer • ~~1 outside southeast side of 2025E~~	Support equipment for spill response

J.4.6 Incident Command Post

The ICPs for the ~~ETF/~~LERF and 200 Area ETF are in the 200 Area ETF ~~e~~Control ~~r~~Room or 2025-EA. Emergency resource materials are stored at each location. The IC could activate the Hanford Fire Department Mobile Command Unit if necessary.

J.5 Required Reports

Post incident, written reports are required for certain incidents on the Hanford Site. The reports are described in Permit Attachment 4, *Hanford Emergency Management Plan*, (DOE/RL-94-02), Section 5.1.

Facility management must note in the Hanford Facility Operating Record, LERF & 200 Area ETF File, the time, date and details of any incident that requires implementation of the contingency plan (refer to Section J.3). Within ~~fifteen (~~15~~)~~ days after the incident, a written report must be submitted to Ecology. The report must include the elements specified in WAC 173-303-360(2)(k).

J.6 Plan Location and Amendments

Copies of this plan are maintained at the following locations:

- 200 Area ETF ~~e~~Control ~~r~~Room
- Building 2025EA ICP

This plan will be reviewed and immediately amended as necessary, in accordance with Permit Attachment 4, *Hanford Emergency Management Plan*, (DOE/RL-94-02), Section 14.3.1.1.

J.7 Facility/Building Emergency Response Organization

~~ETF/~~LERF and 200 Area ETF Building Emergency Directors		
TITLE	**WORK LOCATION**	**WORK PHONE**
Shift Operation Manager (SOM)	2025-E Building	373-9000 or 373-9500

Names and home telephone numbers of the BEDs are available from the POC (373-3800) in accordance with Permit Condition II.A.4.

Quarter Ending September 30, 2014

24590-WTP-PCN-ENV-14-002

Hanford Facility RCRA Permit Modification Notification Form
Part III, Operating Unit 10
Waste Treatment and Immobilization Plant

Index

Page 2 of 4: Hanford Facility RCRA Permit, Part III, Operating Unit 10, Waste Treatment and Immobilization Plant
Environmental Risk Assessment Work Plan for the Hanford Tank Waste Treatment and Immobilization Plant in accordance with DWP Condition III.10.C.11.a.

Submitted by Co-Operator:

Roger J. Landon 7/21/14

Roger J. Landon Date

Reviewed by ORP Program Office:

D. L. Noyes 9/17/14

D. L. Noyes Date

Quarter Ending September 30, 2014

24590-WTP-PCN-ENV-14-002

Hanford Facility RCRA Permit Modification Notification Form	
Unit: **Waste Treatment and Immobilization Plant**	Permit Part: **Part III, Operating Unit 10**

Description of Modification:

The purpose of this Class 1 prime modification is to provide the final Environmental Risk Assessment Work Plan for the Hanford Tank Waste Treatment and Immobilization Plant in accordance with DWP Condition III.10.C.11.a.

This permit modification requests that the final risk assessment work plan be updated in the DWP Appendix 6, as follows:

Appendix 6.1			
Replace:	24590-WTP-RPT-ENS-03-006, Rev 0	With:	Replaced with Appendix 6.2
Appendix 6.1.1			
Replace:	24590-RPT-W375-EN00001, Rev 1	With:	Replaced with Appendix 6.2
Appendix 6.1.2			
Replace:	DOE-01-EQD-021	With:	Replaced with Appendix 6.2
Appendix 6.2			
Replace:	Risk Assessment Work Plan (RESERVED)	With:	Final Risk Assessment Work Plan: 24590-WTP-RPT-ENV-14-002, Rev 0, *Environmental Risk Assessment Work Plan for the Hanford Tank Waste Treatment and Immobilization Plant*
Appendix 6.2.1			
Add:	Supplement 1		24590-WTP-RPT-ENV-10-001, Rev 0, *Constituents of Potential Concern for the WTP Air and Dangerous Waste Permits*
Appendix 6.2.2			
Add:	Supplement 2		24590-WTP-RPT-PO-03-008, Rev 2, *Integrated Emissions Baseline Report for the Hanford Tank Waste Treatment and Immobilization Plant*
Appendix 6.2.3			
Add:	Supplement 3		24590-WTP-HAC-50-00001, Rev C, *Estimated Organic Emissions from Process Cells*
Appendix 6.2.4			
Add:	Supplement 4		24590-WTP-RPT-ENS-07-002, Rev 0, *Chemical Parameters and Toxicological Inputs for the Environmental Risk Assessment for the Hanford Tank Waste Treatment and Immobilization Plant*
Appendix 6.2.5			
Add:	Supplement 5		24590-WTP-RPT-ENV-08-001, Rev 2, *Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol*

This modification requests Ecology approval and incorporation into the permit the specific changes to the final Environmental Risk Assessment Work Plan that were made to address comments received from Ecology. The comments were addressed and proposed revisions to the final Environmental Risk Assessment Work Plan were made in consultation with Ecology, as required by DWP Condition III.10.C.11.a.

Quarter Ending September 30, 2014

24590-WTP-PCN-ENV-14-002

The following identifies the significant changes that have been made on the attached final Environmental Risk Assessment Work Plan:

- The document was renumbered and revised to incorporate changes that address Ecology comments.
- The American Indian scenarios were modified to incorporate the U.S. Department of Energy scenario in the document and to discuss the scenarios of Confederated Tribes of the Umatilla Indian Reservation and the Yakama Nation in the uncertainty section of the document.
- The process to identify the Constituents of Potential Concern, 24590-WTP-RPT-ENV-10-001, *Constituents of Potential Concern for the WTP Air and Dangerous Waste Permits*, was added as Supplement 1.
- Supplement 2 includes 24590-WTP-RPT-PO-03-008, *Integrated Emissions Baseline Report for the Hanford Tank Waste Treatment and Immobilization Plant.* Supplement 2 will be updated in accordance with DWP Condition III.10.C.11.b.
- Supplement 3 includes 24590-WTP-HAC-50-00001, *Estimated Organic Emissions from Process Cells.* Supplement 3 will be updated in accordance with DWP Condition III.10.C.11.b.
- The physical property and toxicity data were moved to Supplement 4, 24590-WTP-RPT-ENS-07-002, *Chemical Parameters and Toxicological Inputs for the Environmental Risk Assessment for the Hanford Tank Waste Treatment and Immobilization Plant.* Supplement 4 will be updated in accordance with DWP Condition III.10.C.11.b.
- Supplement 5 includes 24590-WTP-RPT-ENV-08-001, *Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol.*

As required by DWP Condition III.10.C.11.a., the final Environmental Risk Assessment Work Plan addresses the following:

DWP Condition III.10.C.11.a.:	Appendix 6.2 Environmental Risk Assessment Work Plan:
III.10.C.11.a.i EPA guidance for performance of Human Health and Ecological Risk Assessments for Hazardous Waste Combustion Facilities current at the time of the submittal, assuming both residential and non-residential use scenarios;	24590-WTP-RPT-ENV-14-002; incorporated by reference: • EPA. 2005. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, Final, EPA/530/R-05/006. US Environmental Protection Agency, Washington, DC. • EPA. 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, Peer Review Draft, EPA 530-D-99-001A. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.
III.10.C.11.a.ii Toxicity data current at the time of the submittal;	Supplement 4, 24590-WTP-RPT-ENS-07-002
III.10.C.11.a.iii Compounds newly identified or updated emissions data from current waste characterization and emission testing;	Supplement 1, 24590-WTP-RPT-ENV-10-001
III.10.C.11.a.iv Air modeling updated to include stack gas parameters based on most current emissions testing and WTP Unit design;	Supplement 5, 24590-WTP-RPT-ENV-08-001

Quarter Ending September 30, 2014

24590-WTP-PCN-ENV-14-002

III.10.C.11.a.v Physical/transport properties of constituents, current at the time of the submittal;	Supplement 4, 24590-WTP-RPT-ENS-07-002
III.10.C.11.a.vi Process Description based on most current WTP Unit design;	DWP Chapter 4, Section 4.1, Process Description
III.10.C.11.a.vii Emissions data and all supporting calculations based on most current WTP Unit;	Supplement 2, 24590-WTP-RPT-PO-03-008, and Supplement 3, 24590-WTP-HAC-50-00001
III.10.C.11.a.viii Update of receptor locations based on land use or land use zoning changes, if any.	24590-WTP-RPT-ENV-14-002, Section 6

In accordance with Permit Condition III.10.C.2.e, this permit modification sent to Ecology may include page changes to the Permit, attachments, and permit application supporting documentation.

WAC 173-303-830 Modification Class:	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:		X		

Enter relevant WAC 173-303-830, Appendix I Modification citation number: N/A

Enter wording of WAC 173-303-830, Appendix I Modification citation:

In accordance with WAC 173-303-830(4)(d)(i), this modification notification is requested to be reviewed and approved as a Class 1 modification. WAC 173-303-830(4)(d)(ii)(A) states, "Class 1 modifications apply to minor changes that keep the permit current with routine changes to the facility or its operation. These changes do not substantially alter the permit conditions or reduce the capacity of the facility to protect human health or the environment. In the case of Class 1 modifications, the director may require prior approval."

Modification Approved/Concur: [✓] Yes [ ] Denied (state reason below)

Reason for denial:

Reviewed by Ecology:

S. Dahl 5.2.16

S. Dahl Date

Issued by
RPP-WTP PDC

R50045262

Environmental Risk Assessment Work Plan for the Hanford Tank Waste Treatment and Immobilization Plant

Document title:

Document number: 24590-WTP-RPT-ENV-14-002, Rev 0

Contract deliverable number: Table C.5-1.1, Deliverable 7.6

Contract number: DE-AC27-01RV14136

Department: ESH Environmental Protection

Author(s): D Blumenkranz

Checked by: L Bostic

Issue status: Approved

Approved by: R Landon

Approver's position: Environmental Protection Manager

Approver's signature: Roger J Landon *Signature* 7/16/14 *Date*

This bound document contains a total of 582 sheets

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Notice

Please note that source, special nuclear, and byproduct materials, as defined in the Atomic Energy Act of 1954 (AEA), are regulated at the US Department of Energy (DOE) facilities exclusively by DOE acting pursuant to its AEA authority. DOE asserts that, pursuant to the AEA, it has sole and exclusive responsibility and authority to regulate source, special nuclear, and byproduct materials at DOE-owned nuclear facilities. Information contained herein on radionuclides is provided for process description purposes only.

1

History Sheet

Rev	Reason for revision	Revised by
0	This document incorporates comments received from the Washington Department of Ecology and the US Environmental Protection Agency (see CCNs 175994, 248585, 248586, 248587, 263685, and 263688). This document supersedes document 24590-WTP-RPT-ENS-03-006, Rev 2.	D Blumenkranz

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Supplement 2 *Integrated Emissions Baseline Report for the Hanford Tank Waste Treatment and Immobilization Plant* (24590-WTP-RPT-PO-03-008) S2-i

Supplement 3 ***Estimated Organic Emissions from Process Cells*** **(24590-WTP-HAC-50-00001).....S3-i**

Supplement 4 ***Chemical Parameters and Toxicological Inputs for the Environmental Risk Assessment for the Hanford Tank Waste Treatment and Immobilization Plant*** **(24590-WTP-RPT-ENV-14-003).....S4-i**

Supplement 5 ***Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol*** **(24590-WTP-RPT-ENV-08-001).....S5-i**

Acronyms and Abbreviations

ADAF	age dependent adjustment factors
ADD	average daily dose
AE	absorption efficiency
AEGL	acute exposure guideline level
AHQ	acute hazard quotient
AIEC	acute inhalation exposure criterion
APCS	air pollution control system
AR	arylhydrocarbon receptor
AREC	acute radionuclide exposure criterion
AREL	acute reference exposure level
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	area use factor
BAF	bioaccumulation factor
BCF	bioconcentration factor
BEF	bioaccumulation equivalency factor
BIF	boiler and industrial furnace
BLM	US Bureau of Land Management
CalEPA	California Environmental Protection Agency
CAS	Chemical Abstract Services
CDE	committed dose equivalent
CFR	*Code of Federal Regulations*
CLUP	*Comprehensive Land-Use Plan*
COPC	chemical of potential concern
CSEFH	Child-Specific Exposure Factors Handbook

CSF	cancer slope factor
CSM	conceptual site model
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DCF	dose conversion factor
DD	daily dose
DEM	digital elevation model
DNA	deoxyribonucleic acid
DOE	US Department of Energy
DQO	data quality objective
DST	double-shell tank
DW	dry weight
DWP	Dangerous Waste Permit
EC	exposure concentration
ECF	elevation correction factor
Eco-SSL	Ecological Soil Screening Level
Ecology	Washington State Department of Ecology
EDL	estimated detection limit
EFH	Exposure Factors Handbook
EIS	Environmental Impact Statement
EPA	US Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ERPG	Emergency Response Planning Guideline
ESB	Equilibrium Partitioning Sediment Benchmark
ESQ	ecological screening quotient
ESU	evolutionarily significant unit

ETF	Effluent Treatment Facility
FCM	food chain multiplier
FCV	final chronic value
FEALE	Fitzner-Eberhardt Arid Lands Ecology Reserve
FGR	Federal Guidance Report
FR	*Federal Register*
FRA	final risk assessment
FW	fresh weight
FWS	US Fish and Wildlife Service
GAF	gastrointestinal absorption factor
HAB	Hanford Advisory Board
HEAST	Health Effects Assessment Summary Table
HEME	high-efficiency mist eliminator
HEPA	high-efficiency particulate air
HHRA	human health risk assessment
HHRAP	Human Health Risk Assessment Protocol
HI	hazard index
HLW	high-level waste
HOP	high-level waste melter process system
HQ	hazard quotient
IAEA	International Atomic Energy Agency
IHLW	immobilized high-level waste
ILAW	immobilized low-activity waste
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
ISCST3	Industrial Source Complex Short Term Model, Version 3

ISMS	integrated safety management system
IWAQM	Interagency Workgroup on Air Quality Modeling
IX	ion exchange
LADD	lifetime average daily dose
LAW	low-activity waste
LERF	Liquid Effluent Retention Facility
LOAEL	lowest observed adverse effect level
LOP	low activity waste primary offgas process system
LVP	low activity waste secondary offgas/vessel vent process system
MDL	method detection limit
MM5	Mesoscale Model 5
MSA	Mission Support Alliance
MSL	mean sea level
MTCA	*Model Toxics Control Act*
MW	molecular weight
NAAQS	National Ambient Air Quality Standard
NAWQC	National Ambient Water Quality Criteria
NCEA	National Center for Environmental Assessment
NCR	Nuclear Regulatory Commission
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
ORP	Office of River Protection
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl

PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
pCi	picocurie
PEF	particulate emission factor
PIC	product of incomplete combustion
PJM	pulse jet mixer
PJV	pulse jet ventilation system
PNNL	Pacific Northwest National Laboratory
PRA	pre-demonstration test risk assessment
PSD	prevention of significant deterioration
PT	Pretreatment (Facility)
PVP	pretreatment vessel vent process system
PVV	pretreatment process vessel vent extraction
PWD	plant wash and disposal system
QF	quality factor
RAGS	EPA's *Risk Assessment Guidance for Superfund*
RAWP	risk assessment work plan
RCRA	Resource Conservation and Recovery Act
RDL	reliable detection limit
RCF	root concentration factor
RF	risk factor
RfC	reference concentration
RfD	reference dose
RFD	reverse flow diverter
RME	reasonable maximum exposure
ROD	Record of Decision

ROPC	radionuclide of potential concern
RPF	relative potency factor
RSL	Regional Screening Level
SBS	submerged bed scrubber
SCR	selective catalytic reduction
SCV	secondary chronic value
SF	slope factor
SFr	soil or sediment ingestion fraction
SLERA	screening-level ecological risk assessment
SLERAP	Screening-Level Ecological Risk Assessment Protocol
SLRA	screening-level risk assessment
SSFM	steady-state flowsheet model
SVOC	semivolatile organic compound
T&E	threatened and endangered
TAP	toxic air pollutant
TC&WM	Tank Closure and Waste Management
TCDD	tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofuran
TCE	trichloroethylene
TEDF	Treated Effluent Disposal Facility
TEEL	temporary emergency exposure limit
TEF	toxicity equivalency factor
TEQ	toxic equivalency
TIC	tentatively identified compound
TLP	treated low activity waste evaporation process system
TOE	total organic emissions

TRU	transuranic
TRV	toxicity reference value
TSS	total suspended solids
TUF	temporal use factor
TWRS	Tank Waste Remediation System
UHC	underlying hazardous constituent
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UR	unit risk
URF	unit risk factor
USGS	US Geological Survey
USLE	Universal Soil Loss Equation
UTS	Universal Treatment Standards
VOC	volatile organic compound
WAC	waste acceptance criteria
WESP	wet electrostatic precipitator
WHO	World Health Organization
WTP	Hanford Tank Waste Treatment and Immobilization Plant
YN	Yakama Indian Nation

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Glossary

Abated emissions	Emissions that have passed through WTP process mechanisms or air pollution control equipment to reduce the potential for public exposure consistent with applicable air permitting requirements.
Abiotic	Non-living; used to describe air, soil, sediment, and water to which receptors may be exposed.
Anadromous	Describing fish that spend most of their adult lives in salt water and migrate to freshwater rivers and lakes to reproduce.
Animal fraction (F_A)	Fraction of a receptor's diet that is animal or prey (unitless).
Benthic	Having to do with sediment at the bottom of a stream, pond, river, or lake.
Bioaccumulation factor (*BAF*)	Uptake factor for direct and indirect transfer of chemicals from abiotic medium and food to an organism, expressed as the ratio of the concentration of a chemical in an organism and the concentration of the chemical in an abiotic medium that is a direct source of the chemical for the organism and which the organism's food is also exposed.
Bioaccumulation factor for an animal product	The ratio of the chemical concentration in fresh weight tissue to the daily intake of the chemical by the animal.
Bioconcentration factor (*BCF*)	Uptake factor for direct transfer of chemicals from abiotic medium only to an organism, expressed as the ratio of the concentration of a chemical in an organism and the concentration of the chemical in an abiotic medium that is a direct source of the chemical for the organism.
Biomagnification factor (*BMF*)	The ratio of the concentration of a chemical in a consumer and the concentration of the chemical in its food.
CALPUFF	An air dispersion model. This model handles winds more realistically than the ISCST3 model.
Cancer Slope Factor (*CSF*)	Plausible upper-bound estimate (for chemicals) and central estimate (for radionuclides) of the probability of a cancer response per unit intake over a lifetime.
Carnivore	An animal that eats other animals.

Conservation of mass	The conservation of mass is a fundamental concept of physics. Within a defined system, the amount of mass remains constant (that is, mass cannot be created from nothing). For this discussion, the defined system is the release of chemical emissions from the WTP, subsequent deposition to soil, and uptake into biological organisms.
Conservative	Used in the RAWP to refer to conditions that implicitly or explicitly overestimate exposure. In some cases the word "conservative" is used to refer to procedures that result in higher risks than would have been calculated by explicitly using methods in the guidance.
Default	A predetermined numerical value that is used in place of a missing value.
Dose	The amount of a chemical taken in by an organism.
Driver	A COPC or ROPC that contributes 10 % or more of the threshold incremental lifetime cancer risk for human risk, or 10 % or more of the threshold hazard index for human or ecological risk.
EC_{20}	The lowest chronic exposure that would reduce population recruitment by 20%.
Exposure duration (*ED*)	Time period (typically in years) over which a receptor is exposed.
Estimated Exposure Level (*EEL*)	The mass of constituent per mass of media [communities] or mass daily dose constituent ingested per mass body weight-day [class-specific guilds] of ecological receptors. EEL is the same as the daily dose (DD).
Exposure frequency (*EF*)	Number of days each year during which a receptor is exposed.
Exposure time (*ET*)	Number of hours per exposure event in which a receptor is exposed.
Exposure Point Concentration (EPC)	A concentration to which a receptor is exposure via an inhalation, ingestion, or adsorption pathway.
Ecological screening quotient (*ESQ*)	The ratio of the constituent estimated exposure level (EEL) and the toxicity reference value (TRV). An ESQ value in excess of one is indicative of a potential risk issue.
Feed	For the animals included in this discussion (cattle, wild game, swine, poultry, and wildfowl), feed may include forage, grain, or silage.

Flue	A pipe or tube conveying air and other abated air contaminants to the environment. Each WTP facility has several flues dedicated to process and vessel ventilation, pulse jet mixer, process cell, and building exhaust. Flues from each of the three main WTP facilities are bundled together into a structural steel lattice that is referred to as the facility's stack or effective stack.
Food chain	A sequence of discrete feeding relationships between different species populations or groups of similar organisms.
Food chain multiplier (*FCM*)	A food chain multiplier is the ratio of a bioaccumulation factor to the bioconcentration factor. A food chain multiplier is used to estimate the concentration of a chemical in a predator eating prey. Ratios of FCMs are used in wildlife exposure modeling for a predator to account for the increase in the concentration of a chemical as it moves from an animal to its predator.
Forage	Primarily pasture grass and hay, including wild vegetation, exposed to wet and dry deposition, air-to-plant transfer, and root uptake of contaminants.
Fugitive emissions	Emissions of air contaminants that do not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening. As discussed in Section 3, all process vessels and piping are located inside the Pretreatment, LAW vitrification, or HLW Vitrification buildings. Each building has a separate HVAC system that handles emissions from the process equipment (including leaks or spills). Process piping between buildings is double lined and therefore does not contribute to fugitive emissions. However, the building ventilation system abates only particles or aerosols; vapors effectively pass through the building filters and are emitted. These emissions are addressed as unabated emissions.
Grain	Barley, wheat, or similar protected seed product (domestic and wild), limited to exposure to contaminants solely through root uptake.
Hanford offsite maximum	Location of maximum predicted ground-level concentrations of both airborne and deposited emissions outside the Hanford Site boundary. This location will have the highest modeled exposures on land that DOE does not control.
Herbivore	An animal that eats primarily plant material.
Home Range (*HR*)	The area an ecological receptor occupies for breeding, hunting, and or grazing.
Human Health Risk Assessment Protocol (HHRAP)	The human health risk assessment guidance document (EPA. 2005. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, Final, EPA/530/R-05/006).
Insectivore	An animal that eats primarily insects and other invertebrates.

ISCST3	Industrial Source Complex Short-Term Model; an earlier air dispersion model used by the WTP, now replaced by CALPUFF.
Joule-heated	Heated by passing an electric current directly through the material.
LD50	The median lethal dose of a substance, or the amount required to kill 50% of a given test population.
LOAEL	Lowest observed adverse effect level; the lowest dose of a toxic chemical that caused an observable adverse effect in a toxicity test on the endpoint being measured; if the range of doses tested did not include a dose low enough to cause a NOAEL (no observed adverse effect level), it is not possible to determine how close the LOAEL is to a no adverse effect level dose.
Mass density	The weight of material in a unit area given a specified soil depth.
Mass-limited uptake factor	An uptake factor that results in 100 % of an available chemical being transferred into a biological receptor but no more.
mGy	MilliGray, a unit of absorbed radiation equal to 0.001 Joule/kg.
NOAEL	No observed adverse effect level; the highest dose of a toxic chemical that did not cause any observable adverse effect in a toxicity test on the endpoint being measured; if the range of doses tested did not include a dose high enough to cause a LOAEL, it is not possible to determine how close the NOAEL is to an adverse effect level.
Omnivore	An animal that eats both plants and animals.
Onsite ground maximum	Location of maximum predicted ground-level concentrations of both airborne and deposited emissions on the Hanford Site. This location will have the highest modeled exposures for current workers on the Hanford Site and for ecological receptors.
Planktivorous	Describing fish that eat plankton.
Plant fraction (F_P)	Fraction of a receptor's diet that is plant (unitless).
Plausible	Describing exposure scenarios for receptors that currently exist, or may reasonably be expected to exist in the future, at a given location (for example, a future resident at the Hanford offsite maximum location). Exposure parameters for plausible scenarios are conservative.

Product of incomplete combustion (PIC)	A chemical produced when combustion of an organic COPC does not completely convert the COPC to carbon dioxide and oxides of nitrogen, sulfur, and/or any other element that makes up the chemical structure of the COPC.
Quality Factor *(QF)*	A factor that describes the relative biological activity (i.e., quality) of alpha radiation compared to gamma radiation.
rad	A unit of absorbed radiation equal to 0.01 Joule/kg.
Regression	A mathematical method that determines how closely an equation fits a series of data points. Regression can be used to derive a generalized equation from a number of observed values, for example, the equations to calculate bioaccumulation factors from $\log_{10} K_{ow}$ values.
Root Concentration Factor (*RCF*)	A factor used to calculate the belowground transfer of a chemical from the soil to a root vegetable.
Sensitive species EC_{20}	A benchmark calculated from chronic toxicity test data that is intended to allow no more than a 20 % reduction in weight or number of offspring in 95 % of species.
Silage	Vegetation and livestock feed that has been stored and fermented, exposed to wet and dry deposition, air-to-plant transfer, and root uptake of contaminants. Silage is limited to consumption by domestic livestock.
SLERAP	Screening-level ecological risk assessment protocol; the ecological risk assessment guidance document (EPA. 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities,* Peer Review Draft, EPA 530-D-99-001A).
Soil pore water	Water in the interstitial spaces between the mineral and organic particles of soil.
Stack	A structural steel lattice that supports individual flues from each of the WTP's three main facilities. Stack parameters important to air dispersion modeling including flow rate, temperature and velocity can be calculated arithmetically as the weighted average of the combined flues within the steel lattice.
Steady state	The condition where the value of a variable does not change through time.
Surrogate	A chemical with known bioaccumulation or toxicity factors which are used in lieu of those factors for a COPC for which the factors are not known. The surrogate is sufficiently chemically similar to the COPC that the COPC is expected to have similar bioaccumulation or toxicity factors to those of the surrogate.

T&E species	Plant and animal species that have been designated by law as threatened or endangered.
Target analyte	An analyte that is expected to occur in WTP airborne emissions and can readily be identified and quantified by chemical analytical methods that will be used at the WTP.
Temporal-Use Factor (*TUF*)	Fraction of time each year that an ecological receptor is in the vicinity of the exposure location during which it forages or resides at the exposure location. The TUF will be assumed to be 1 for all receptors.
Tentatively identified compound (TIC)	A compound that is detected in environmental samples that is not a target analyte. TICs are identified generally as a result of using mass spectrometry techniques. When a TIC is identified, it can be definitively identified by analyzing an authentic standard of the putative unknown.
Tilled soil	Soil evenly mixed down to a depth of 20 cm.
Toxicity Equivalance Factor	The ratio of toxicity of a polychlorinated dibenzodioxin, dibenzofuran, and biphenyl COPC to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin.
Toxicity Reference Values (*TRV*)	A threshold value used to characterize ecological risk based upon a hierarchy of toxicological data.
Unabated emissions	Emissions of air contaminants that would result if all abatement control equipment in the WTP did not exist, but operations were otherwise normal. There will be no unabated emissions from the process flues at the WTP facility at any time. There is the possibility that a fraction of waste being treated by the WTP will leak or spill from ancillary equipment such as valves, equipment seals, and connectors and enter WTP's process cells. Process cell ventilation will pass through HEPA filtration prior to discharge to the environment, however a portion of the organics that are vapor phase will not be abated by HEPA filters. These emissions are referred to as process cell organic emissions and have been estimated and included along with the abated process emissions for purposes of this risk assessment.
Untilled soil	Soil evenly mixed down to a depth of 2 cm.
Uptake factor	The ratio of a chemical concentration in one environmental medium to its concentration in another.
Vapor Partitioning Coefficient (F_v)	Fraction of the COPC or ROPC air concentration in vapor phase (unitless). Particle phase constituents are defined as having an $F_v < 0.05$ (that is, having a vapor concentration of less than 5 percent). Vapor phase constituents have an $F_v = 1$. A subset of organic COPCs falls into the category of particle-bound ($0.05 < F_v < 1$). Particle-bound constituents have a portion of vapor condensed onto the particle surface.

Wetland	An area whose soil is saturated with water; saturation causes low oxygen concentrations in the soil and results in the growth of plants specialized to live with low oxygen levels.
Worst-case	Describing exposure scenarios for receptors that are not reasonably expected to exist now or in the future at the specified location (for example, a future resident at the onsite ground maximum location). Exposure parameters for worst-case scenarios are conservative.

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1 Symbol Glossary

A	area of exposure for an ecological receptor
a	empirical intercept coefficient
A_{beef}	concentration of constituent in beef
AbF	absorbed fraction of energy from radiation
ACF	area correction factor for an infinite slab
$A_{chicken}$	concentration of constituent in chicken
$ADAF$	age dependent adjustment factor for cancer slope factor for mutagenic chemicals
ADD	average daily dose: for evaluating exposure to noncarcinogenic COPCs, the intake is referred to as average daily dose (ADD)
ADD_{infant}	average daily dose of constituents from breast milk
A_{egg}	concentration of constituent in eggs
A_{fowl}	concentration of a constituent in wildfowl
A_{game}	concentration of a constituent in wild game
AHQ	acute hazard quotient
A_I	area of impervious watershed receiving deposition
A_i	concentration of constituent in animal product i
$AIEC$	acute inhalation exposure criteria
A_L	total watershed area receiving deposition
A_{milk}	concentration of constituent in milk
A_{pork}	concentration of constituent in pork
$AREC_E$	acute radionuclide exposure criteria for external gamma
$AREC_I$	acute radionuclide exposure criteria for inhalation
$AREC_M$	acute radionuclide exposure criteria for ROPC i corrected for the presence of multiple ROPCs

$AREC_R$	total acute radionuclide exposure criteria
AT_C	averaging time is the period over which exposure is averaged. The averaging time for carcinogens is based on a lifetime exposure of 70 years
AT_{infant}	infant averaging time
AT_N	averaging time is the period over which exposure is averaged. For noncarcinogens, AT_N is equal in length to the exposure duration (ED)
AUF	area use factor; the portion or percent of an ecological receptor's home range area used by the receptor
A_w	average annual water body surface area
b	empirical slope coefficient
Ba_{beef}	biotransfer factor for beef, expressed as the ratio of the chemical concentration in fresh weight tissue to the daily intake of the chemical by beef cattle
$Ba_{chicken}$	biotransfer factor for chickens, expressed as the ratio of the chemical concentration in fresh weight tissue to the chemical intake from the feed by chickens
Ba_{deer}	biotransfer factor for wild game animals
Ba_{egg}	biotransfer factor for eggs, expressed as the ratio of the chemical concentration in fresh weight tissue to the chemical intake from the feed by chickens
BAF	bioaccumulation factor
BAF_{fish}	bioaccumulation factor for a constituent in fish
BAF_{organs}	organ-specific bioaccumulation factor for a constituent in fish
Ba_{milk}	biotransfer factor for milk, expressed as the ratio of the chemical concentration in fresh weight tissue to the daily intake of the chemical by milk cows
Ba_{pork}	biotransfer factor for pork, expressed as the ratio of the chemical concentration in fresh weight tissue to the daily intake of the chemical by swine
BCF	uptake factor for direct transfer of chemicals from abiotic medium only to an organism, expressed as the ratio of the concentration of a chemical in an organism and the concentration of the chemical in an abiotic medium that is a direct source of the chemical for the organism
BCF_A	generic notation for animal bioconcentration factor, used to calculate the transfer of a constituent from the exposure media to the animal
BCF_{fish}	fish bioconcentration factor, used to calculate the transfer of a constituent from surface water to a fish

BCF_i	generic notation for the media-to-animal or media-to-plant bioconcentration factor for constituent *i* in the exposure media
BCF_{inv}	aquatic invertebrate bioconcentration factor, used to calculate the transfer of a constituent from surface water to an aquatic invertebrate
BCF_P	plant bioconcentration factor, used to calculate the transfer of a constituent from plant to an animal
BCF_r	soil-to-plant bioconcentration factor, used to calculate the transfer of a constituent from soil, sediment, or water to a plant
BCF_S	soil bioconcentration factor, used to calculate the transfer of a constituent from soil or sediment to a plant or animal
BCF_W	water bioconcentration factor, used to calculate the transfer of a constituent from water to a plant or animal
BD	soil bulk density
BEF	the ratio of bioaccumulation of a polychlorinated dibenzodioxin, dibenzofuran, or biphenyl COPC to the bioaccumulation of 2,3,7,8-tetrachlorodibenzo-p-dioxin
Br	soil-to-plant uptake factor; uptake is through roots or root hairs
BR	breathing rate of standard man
Br_{ag}	soil-to-plant uptake factor for aboveground plants, accounting for the uptake from soil and the subsequent transport of chemicals through the roots to the aboveground parts of a plant
$Br_{rootveg}$	soil-to-plant uptake factor for chemicals in root vegetables, accounting for the uptake from soil to the belowground root vegetable or produce
Bs	soil bioavailability factor
$BSAF_{fish}$	biota-to-sediment accumulation factor for fish
Bv_{ag}	constituent air-to-plant biotransfer factor for aboveground plant
BW	total body weight of a receptor (adult or child)
BW_{infant}	infant body weight
C	USLE cover management factor
C_A	concentration of a COPC or ROPC in the tissue of an animal receptor resulting from ingestion of contaminated soil, sediment, water, and food
C_a	concentration of a COPC or ROPC in air resulting from WTP airborne emissions

$C_{A(C\text{-}14)}$	concentration of carbon-14 in the surrounding air
$C_{A(H\text{-}3)}$	concentration of tritium in the surrounding air
C_{acute}	one-hour acute air concentration
C_{AP}	concentration of a COPC or ROPC in aquatic plants resulting from uptake of WTP airborne emissions directly and from water
C_{BS}	bed sediment concentration
CDE	committed dose equivalent
$CDE+D$	committed dose equivalent for radionuclide i and its daughter products
CDE_i	committed dose equivalent for radionuclide i
C_{dw}	dissolved-phase water concentration of constituent
C_{fish}	concentration of constituent in fish
C_{forage}	modeled concentration in forage
C_{grain}	modeled concentration in grain
C_i^{GRAV}	stack concentration of ith identified nonvolatile COPC
C_i^{SVOC}	stack concentration of ith identified semivolatile COPC
C_i^{VOC}	stack concentration of ith identified volatile COPC
C_M	generic notation for the concentration of a COPC or ROPC in exposure media such as air, soil, water and sediment
$C_{milkfat}$	concentration of constituent in milk fat of breast milk for a specific exposure scenario of a nursing mother
COPC	chemical of potential concern
C_p	concentration of a COPC or ROPC in plants resulting from uptake of WTP airborne emissions directly and from soil
C_{pw}	concentration of a COPC or ROPC in soil pore water resulting from deposition of WTP airborne emissions
CR_{forage}	consumption rate of forage by a receptor (quantity consumed per day)
CR_{grain}	consumption rate of grain by a receptor (quantity consumed per day)
CR_i	consumption rate of animal product i

CR_{silage}	consumption rate of silage by a receptor (quantity consumed per day)
CR_{soil}	consumption rate of soil by a receptor (quantity consumed per day)
Cs	concentration in soil
Cs_2	soil concentration at the 2 cm soil depth (untilled soil)
Cs_{15}	soil concentration at the 15 cm soil depth (root zone)
Cs_{20}	soil concentration at the 20 cm soil depth (tilled soil)
C_{sed}	constituent concentration in bed sediment
CSF	Cancer Slope Factor: plausible upper-bound estimate (for chemicals) and central estimate (for radionuclides) of the probability of a cancer response per unit intake over a lifetime
CSF_{adj}	adjusted cancer slope factor for 2 cm depth
CSF_{dermal}	dermal cancer slope factor
CSF_{food}	radionuclide-specific food ingestion cancer slope factor
CSF_i	constituent-specific external pathway cancer slope factor for pathway *i*
CSF_{o_i}	radionuclide-specific oral (ingestion) pathway cancer slope factor for pathway *i*
CSF_{water}	radionuclide-specific water ingestion cancer slope factor
C_{silage}	modeled concentration in silage
C_{soil}	modeled concentration in soil
Cs_{tD}	maximum soil concentration; occurs at the time emissions cease
C_{TP}	concentration of a COPC or ROPC in terrestrial plants resulting from uptake of WTP airborne emissions directly and from soil and air
$C_{V(C\text{-}14)}$	concentration of carbon-14 in vegetation
$C_{V(H\text{-}3)}$	concentration of tritium in vegetation
C_{wctot}	total constituent concentration in the water column
C_{wtot}	total water body constituent concentration, including the water column and bed sediment

Cyp	unitized yearly average air concentration from particles Cyp, from the air dispersion modeling, is stack-specific (subscript 1 for 1 micron particle size [Cyp_1], subscript 2.5 for 2.5 micron particle size [$Cyp_{2.5}$])
Cyv	unitized yearly average air concentration from vapor Cyv, from the air dispersion modeling, is stack-specific
d_{bs}	depth of the upper benthic sediment layer
DCF	dose conversion factor, a multiplier used to convert the concentration of an ROPC in air, soil, or water to the external radiation dose absorbed by a receptor
DD	daily dose; the amount of a chemical taken in by an organism per unit body weight each day (mg/kg of receptor body weight per day)
$DD_{belowgrd}$	external dose from exposure to belowground soil
$DD_{E_{air}}$	external radiation dose from airborne ROPCs surrounding the receptor
$DD_{E_{sed}}$	external radiation dose from ROPCs in sediment due to immersion in sediment and/or sediment/water interface
$DD_{E_{soil}}$	external radiation dose from ROPCs in soil to a receptor that either is immersed in soil or is on or near the surface of the soil
$DD_{E_{water}}$	external radiation dose from ROPCs in water; receptor either is immersed in water or is on or near the surface of the water
DD_I	internal radiation dose to a receptor due to the receptor's own tissue concentration of ROPCs
DD_{imm}	external radiation dose from ROPCs in water to a receptor that is immersed in water
DD_{near}	external radiation dose from ROPCs in water to a receptor that is above but near the surface of the water
$DF_{abovegrd}$	factor for converting activity of radionuclide in soil to external dose from exposure to aboveground from untilled soil
DF_{air}	factor for converting activity of the ROPC in air to external dose from air
DF_{imm}	factor for converting activity of radionuclide in water to external dose from immersion water
DF_{near}	factor for converting activity of radionuclide in water to external dose from exposure near water, or due to surface water
$DF_{s/w}$	factor for converting activity of radionuclide in sediment/water interface to external dose from exposure to the sediment/water interface

DF_{sed}	factor for converting activity of radionuclide in sediment contact and immersion to external dose from exposure to the sediment
$DF_{sed,imm}$	factor for converting activity of radionuclide in sediment to external dose from exposure due to burial in sediment
DF_{water}	factor for converting activity of radionuclide in water to external dose from exposure to water
DL	dose limit of 0.1 rem (100 mrem)
Ds	deposition term to soil
d_{wc}	average annual depth of the water column
$Dydp$	unitized yearly average dry deposition from particle phase from the air dispersion modeling, is stack-specific (subscript 1 for 1 micron particle size [$Dydp_1$], subscript 2.5 for 2.5 micron particle size [$Dydp_{2.5}$])
$Dydv$	unitized yearly average dry deposition from vapor phase from the air dispersion modeling, is stack-specific (subscript 1 for 1 micron particle size [$Dydv_1$], subscript 2.5 for 2.5 micron particle size [$Dydv_{2.5}$])
$Dywp$	unitized yearly average wet deposition from particle phase from the air dispersion modeling, is stack-specific (subscript 1 for 1 micron particle size [$Dywp_1$], subscript 2.5 for 2.5 micron particle size [$Dywp_{2.5}$])
$Dywv$	unitized yearly average wet deposition from vapor phase from the air dispersion modeling, is stack-specific (subscript 1 for 1 micron particle size [$Dywv_1$], subscript 2.5 for 2.5 micron particle size [$Dywv_{2.5}$])
E	average energy emitted as radiation (MeV per disintegration) × proportion of disintegrations producing radiation (MeV per disintegration)
E_v	evapotranspiration
e	Euler's number, exponential function (base of the natural logarithm, unitless), $e = \sum_{i=0}^{\infty} \frac{1}{i!} \approx 2.718282$
EC_{inh}	exposure concentration of constituents through inhalation of emissions
$EC_{inh_{sweatlodge}}$	exposure concentration of constituents through inhalation in the sweat lodge
ED	exposure duration: time period (typically in years) over which a receptor is exposed
ED_{infant}	infant exposure duration

EEL	Estimated Exposure Level: the mass of constituent per mass of media [communities] or mass daily dose constituent ingested per mass body weight-day [class-specific guilds] of ecological receptors *EEL* is the same as the daily dose (*DD*)
EF	exposure frequency: number of days each year during which a receptor is exposed
EF_{infant}	infant exposure exposure frequency
ESQ	ecological screening quotient: the ratio of the constituent estimated exposure level (*EEL*) and the toxicity reference value (*TRV*) An *ESQ* value in excess of one is indicative of a potential risk issue
ET	exposure time: number of hours per exposure event in which a receptor is exposed
ET_i	receptor-specific exposure time fraction indoors
ET_o	receptor-specific exposure time fraction outdoors
f_1	fraction of ingested Constituent that is stored in fat
f_2	fraction of mother's weight that is fat
f_3	fraction of breast milk that is fat
f_4	fraction of ingested constituent that is absorbed
F_A	animal fraction; fraction of a receptor's diet that is animal or prey
f_{bs}	fraction of total water body constituent concentration in the benthic sediment
FCM	food chain multiplier: A food chain multiplier is the ratio of a bioaccumulation factor to the bioconcentration factor A food chain multiplier is used to estimate the concentration of a chemical in a predator eating prey. Ratios of *FCM*s are used in wildlife exposure modeling for a predator to account for the increase in the concentration of a chemical as it moves from an animal to its predator
F_{fish}	fraction of ingested fish that is contaminated
F_{forage}	fraction of forage grown on contaminated soil and ingested by the animals
F_{grain}	fraction of grain grown on contaminated soil and ingested by domestic livestock
F_i	fraction of ingested soil that is contaminated
F_i	fraction of media *i* that is contaminated for a given exposure pathway
f_i	decay probability of radionuclide *i*
F_{imm}	fraction of time receptor spends immersed in water

f_{lipid}	fish lipid content
F_{near}	fraction of time receptor spends near or swimming on the surface of the water
f_{oc}	fraction of the dry mass of soil consisting of organic carbon, for example, particle-bound, dissolved, or emulsified organic chemicals and decaying plant and animal material
F_P	plant fraction: fraction of a receptor's diet that is plant
$F_{s/w}$	fraction of time receptor spends at the sediment-water interface
F_{sed}	fraction of time receptor spends buried in sediment
F_{TOE}^{GRAV}	total organic emission factor for the nonvolatile fraction
F_{TOE}^{SVOC}	total organic emission factor for the volatile fraction
F_{TOE}^{SVOC}	total organic emission factor for the semivolatile fraction
F_v	vapor partitioning coefficient: fraction of the constituent air concentration in vapor phase
Fw	fraction of constituent wet deposition that adheres to plant surfaces
f_{wc}	fraction of the total water body constituent concentration in the water column
g/s	grams per second
h	biological half-life of COPC or effective half-life of ROPC
h_b	biological half-life of ROPC
HI	hazard index for a specific exposure pathway
HQ	hazard quotient
HR	home range: the area where an ecological receptor for breeding, hunting, and or grazing
h_r	radiological half-life of ROPC
$Humidity$	absolute humidity of the atmosphere
I	irrigation
I_{ag}	intake of constituent through ingestion of produce
I_d	intake of COPCs from adult dermal absorption within the sweat lodge

$I_{d,l}$	intake of COPCs from adult dermal absorption of condensate within the sweat lodge
$I_{d,v}$	intake of COPCs from adult dermal absorption of vapors within the sweat lodge
I_{dw}	intake of constituents from drinking water
I_{fish}	intake of constituent from fish
I_i	intake of constituent from animal product *i*
$I_{inh_{sweatlodge}}$	intake of constituent via inhalation in the sweat lodge
$I_{inhsoil}$	intake of constituent through inhalation of resuspended soil
I_{ira}	external exposure to radiation from ROPCs in air
I_{irs}	external exposure to radiation from ROPCs in soil
I_{soil}	intake of constituent due to soil ingestion
$ILCR$	incremental lifetime cancer risk
$ILCR_e$	incremental lifetime cancer risk from external pathways
$ILCR_{e_{air}}$	incremental lifetime cancer risk due to external exposure to radionuclides in air
$ILCR_{e_{dermal}}$	incremental lifetime cancer risk due to external pathways
$ILCR_{e_{soil}}$	incremental lifetime cancer risk due to external exposure to radionuclides in soil
$ILCR_o$	incremental lifetime cancer risk from oral (ingestion) pathways
IR	inhalation rate
IR_F	daily food ingestion rate
IR_{infant}	daily infant ingestion rate of breast milk
IR_W	daily water ingestion rate
K	USLE erodibility factor
Kd_{bs}	bed sediment/sediment pore water partition coefficient
Kd_s	soil-water partitioning coefficient
Kd_{sw}	suspended sediments/surface water partition coefficient

K_G	gas-phase transfer coefficient
K_{oc}	soil organic carbon-water partitioning coefficient (concentration of chemical in soil, expressed as soil carbon, relative to its solubility in water)
K_{ow}	octanol/water partitioning coefficient (ratio of the solute concentration in the water-saturated octanol phase to the solute concentration in the octanol-saturated water phase)
kp	plant surface loss coefficient
Kp	permeability constant
ks	overall soil loss constant due to all processes
k_{wt}	overall total water body constituent dissipation rate constant
$LADD$	lifetime average daily dose For evaluating exposure to carcinogenic compounds, the intake is referred to as lifetime average daily dose
$LADD_d$	lifetime average daily dose, or intake, I_d, from dermal absorption of condensate and vapors within the sweat lodge
$LADD_i$	lifetime average daily dose, or intake, I, of constituent via ingestion pathway i (dermal absorption, external air and soil exposure)
$LADD_{ira}$	lifetime average daily dose, or intake, I_{ira}, from radiation from ROPCs in air
$LADD_{irs}$	lifetime average daily dose to radiation from ROPCs in soil, I_{irs}, from ROPCs in soil
$LADD_o$	lifetime average daily dose, or intake, of constituent via ingestion
$LADD_{o_i}$	lifetime average daily dose, or intake, of constituent via ingestion pathway i (water ingestion, food ingestion, and soil ingestion, as applicable)
L_{DEP}	total (wet and dry) particle-phase and total (wet and dry) vapor-phase direct deposition load to water body
L_{DIF}	vapor-phase dry deposition diffusion load to water body
L_E	soil erosion load to the surface water body
$LOAEL$	lowest observed adverse effect level
L_R	runoff load from pervious surfaces
L_{RI}	runoff load from impervious surfaces
LS	USLE length-slope factor

L_T	total constituent load to the water body, including deposition, runoff, and erosion
m	maternal intake of constituents from all adult exposures
MF	metabolism factor
MF	modifying factor
MW_w	molar weight of water
n	number of samples in the data set
$NOAEL$	no observed adverse effect level
OC_{sed}	fraction of organic carbon in bottom sediment
P	precipitation
p	ratio of the total annual release time to the total annual time during which photosynthesis occurs
Pd	concentration of constituent in aboveground plant due to direct (wet and dry) deposition
$Pd_{(Hg)}$	concentration of total mercury in aboveground produce due to direct (wet and dry) deposition
$Pd_{(Hg^{2+})}$	concentration of divalent mercury in aboveground produce due to direct (wet and dry) deposition
$Pd_{(MHg)}$	concentration of methyl mercury in aboveground produce due to direct (wet and dry) deposition
$P_{domestic\ grain}$	concentration of a constituent in grain that is ingested by a chicken
PEF	particulate emission factor
PF	USLE supporting practice factor
P_{forage}	concentration of a constituent in forage that is ingested by the wild game
P_i	concentration of constituent in plant type i that is ingested by livestock or game
Pr_{ag}	concentration of constituent in aboveground plant due to root uptake
Pr_{bg}	concentration of constituent in belowground plant due to root uptake
Pv	concentration of constituent in aboveground plant due to air-to-plant transfer
$Pv_{(Hg)}$	concentration of total mercury in aboveground plant due to air-to-plant transfer

$Pv_{(Hg^{2+})}$	concentration of divalent mercury in aboveground plant due to air-to-plant transfer
$Pv_{(MHg)}$	concentration of methyl mercury in aboveground plant due to air-to-plant transfer
$P_{wild\ grain}$	concentration of a constituent in grain that is ingested by a wildfowl
Q	constituent-specific emission rate obtained from calculations after the air dispersion modeling
QF	quality factor: a factor that describes the relative biological activity (ie, quality) of alpha radiation compared to gamma radiation
$Qp_{forage(deer)}$	quantity of forage eaten by the wild game animals per day
$Qp_{forage(i)}$	amount of forage eaten by animal product *i* per day
$Qp_{grain(chicken)}$	quantity of grain eaten by the wildfowl per day
$Qp_{grain(i)}$	amount of grain eaten by animal product *i* per day
$Qp_{i(beef)}$	quantity of plant type *i* eaten by the beef cattle per day
$Qp_{i(chicken)}$	quantity of plant type *i* eaten by the chicken per day
$Qp_{i(milk)}$	quantity of plant type *i* eaten by the dairy cattle per day
$Qp_{i(pork)}$	quantity of plant type *i* eaten by the pork per day
$Qp_{silage(i)}$	amount of silage eaten by animal product *i* per day
$Qs_{soil(beef)}$	quantity of soil ingested by the beef cattle per day
$Qs_{soil(chicken)}$	quantity of soil ingested by the chicken per day
$Qs_{soil(milk)}$	quantity of soil ingested by the dairy cattle per day
$Qs_{soil(pork)}$	quantity of soil ingested by the pork per day
R	ideal gas law constant, $R = 0.08205746$ L·atm/mol·°K
r	radius of sweat lodge
ρ_a	density of air
RCF	root concentration factor: used to calculate the belowground transfer of a chemical from the soil to a root vegetable
RF	USLE rainfall (or erosivity) factor
RF_{air}	radionuclide-specific risk coefficient for morbidity for pathway *i* (external air)

RfC	reference concentration
RfD	reference dose
$Risk_{lifetime}$	combined lifetime risk due to exposure to a specific mutagenic chemical via a specific exposure pathway or exposure media
RO	average annual surface runoff from pervious areas
Rp	interception fraction of the edible portion of plant for aboveground produce
ρ_w	density of liquid water at sweat lodge temperature
s	estimate of standard deviation
SA	body surface area available for contact
Se	shielding factor
SFr	soil (or sediment) fraction is the ratio of the soil (or sediment) ingestion rate to the sum of the plant and animal ingestion rates
SPv	plant bioconcentration factor, used to calculate the transfer of a chemical from soil to a soil-dwelling plant
t	student t-test value for data set
T_1	the time at the start of exposure
T_2	the time at the end of exposure
tD	time period over which deposition occurs (time period of WTP operation)
TEF	the ratio of toxicity of a polychlorinated dibenzodioxin, dibenzofuran, or biphenyl COPC to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin or the ratio of toxicity of a polyaromatic hydrocarbon COPC to that of benzo(a)pyrene
TOE	TOE factor: total organic emissions divided by the sum of the identified organics
$TO_{TOTAL}{}^{GRAV}$	total nonvolatile organic emission
$TO_{TOTAL}{}^{SVOC}$	total volatile organic emission
$TO_{TOTAL}{}^{SVOC}$	total semivolatile organic emission
Tp	length of plant exposure to deposition per harvest of edible portion of plant for aboveground produce
TRV	toxicity reference values: a threshold value used to characterize ecological risk based upon a hierarchy of toxicological data

T_{sl}	temperature of the sweat lodge
TSS	total suspended solids concentration
T_{wk}	water body temperature
T_{wk}	water body temperature
u	current velocity
UCL	upper confidence limit
UF	uncertainty factor
URF	inhalation unit risk factor
Vf_x	average annual volumetric flow rate through the water body
VG_{ag}	empirical correction factor for the aboveground plant due to air-to-plant transfer
$VG_{rootveg}$	empirical correction factor for belowground plants
V_W	volume of water in the sweat lodge
WP	aquatic plant concentration factor, used to calculate the transfer of a chemical from surface water to an aquatic plant
x	arithmetic mean (average) of stack gas concentrations
Yp	site-specific and plant-type-specific yield or standing crop biomass of the edible portion of the plant for aboveground produce (productivity)
Z_s	soil mixing zone depth (s = depth in centimeters)
θ	temperature correction factor
θ_{bs}	bed sediment porosity
θ_{sw}	soil volumetric water content

1

Executive Summary

The purpose of this work plan is to provide the concepts, methods, and data to be used in an environmental risk assessment. The intent of this environmental risk assessment is to evaluate the human health and ecological risk from the potential airborne emissions. It is important that people and the environment are not harmed because potential exposures are overlooked or underestimated, but it is also important to maximize the ability of the facility to dispose of the tank waste and to protect against the potential leakage from these tanks into the nearby Hanford site soil, groundwater, and ultimately, the Columbia River. A balance of these goals will result from the interactive process of reviewing and improving this work plan and subsequent documents that will contain the actual environmental risk assessments. Indeed, each stage of this work will benefit from interactions with regulatory agencies, American Indian tribes, and the public to assure public health and to protect the environment. These interactions are expected to be in the form of questions and comments about methods and data, and other inputs.

Hanford tank wastes consist of approximately 54 million US gallons of highly radioactive and mixed dangerous wastes that are managed by the US Department of Energy. The wastes consist of solids (sludge), liquids (supernatant), and salt cake (dried salts that will dissolve in water to form supernatant). The term low-activity waste (LAW) generally refers to the supernatant portion, while high-level waste (HLW) usually refers to the solids. These wastes are stored in underground holding tanks and will be pumped to the WTP. At the WTP, wastes will be pretreated and immobilized using a technology called *vitrification*. Vitrification is a thermal process that converts the waste materials into durable glass. The vitrified wastes and secondary wastes resulting from the WTP processes will then be transferred to designated treatment, storage, or disposal units. The WTP is scheduled to be in operation for up to 40 years. During the pretreatment and vitrification of the various types of wastes, some airborne emissions will be created. Various engineered devices will control the nature and amounts of these emissions, but there will still be material in the form of vapors and small particles that will be released via three tall stacks into the environment around the WTP.

Once the vapors and particulates leave the facility stacks, they will be carried by air currents and deposited on the surface of soil and vegetation around the WTP and on the surface of the Columbia River. An air-dispersion model named CALPUFF will be used to calculate how the emitted chemicals and radionuclides will be dispersed. Some of the material will enter terrestrial and aquatic food chains, and people and animals can ingest the food that contains small amounts of material from the emissions. The work plan contains details about these processes; pathways and exposures are defined in very explicit ways so that a complete and quantitative risk assessment can be conducted. The work plan presents a thorough explanation of these exposures via various pathways to a variety of receptors for over 400 different chemicals and radionuclides.

The environmental risk assessment will define and evaluate risks, or the potential for harm, to human and ecological receptors within various distances from the WTP. For example, the air-dispersion model will model exposure depositions and concentrations within 50 kilometers of the WTP. The area within 50 kilometers is predominantly located within Benton County in Washington State, and includes parts of Franklin, Grant, Yakima, and Kittitas counties. The Tri-Cities, composed of the cities of Richland, Kennewick, and Pasco, are adjacent to the southern edge of the Hanford Site. The Tri-Cities area

contains a population of approximately 220,000, the majority of whom reside between 30 kilometers and 50 kilometers from the WTP Site (Census Bureau 2009[1]). There are no permanent residents on the Hanford Site, but there are workers. American Indian tribes have treaty rights to resources on the Hanford Site, and the environmental risk assessment will evaluate potential risks from food gathering and social activities. A variety of ecological receptors inhabit the Hanford Site. They include terrestrial and aquatic plants (the basis of the food chains); terrestrial, aquatic, and sediment-dwelling animals; mammals and birds that eat the terrestrial and aquatic plants and animals; and aquatic biota in the Columbia River. Thus, Hanford Site-specific human and ecological receptors will be evaluated in the risk assessments. There will be two types of risk assessments: one focusing on humans (the human health risk assessment) and the other focusing on plants and animals in the environment (the ecological risk assessment).

The human health risk assessment includes four fundamental steps: (1) data evaluation, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization. These steps, as well as the collection of considerable amounts of data and associated estimation methods, are specified by the Washington State Department of Ecology and the US Environmental Protection Agency. The data evaluation step focuses on the selection of the chemicals and radionuclides of potential concern and the quantification of emissions; both of these are described fully in the work plan. Exposure assessment, the second step, deals with estimating the type, extent, and magnitude of potential exposures. The types of human receptors that will be used to calculate quantitative estimates of risk are also established at this step. These receptors are the following: worker, resident (both adult and child), resident subsistence farmer (both adult and child), resident subsistence fisher (both adult and child), American Indian subsistence resident (both adult and child), nursing infant of all adult receptors, and a person who has an acute or short-term exposure. The geographical locations where the people live and work and the exposure pathways are explained in the work plan. The third step is a toxicity assessment, which involves evaluating the potential of the various chemicals and radionuclides to cause adverse health effects in exposed individuals. The toxicity assessment will consider the potential cancer and noncancer effects associated with contaminant exposures. Risk characterization, the fourth step, involves evaluating the exposure and the toxicity information together to estimate the potential for various humans under various conditions to experience adverse effects (cancer and noncancer) as a result of being exposed to the media contaminated by emissions from the WTP. Risks are presented as potential incremental lifetime cancer risk, or noncancer hazard quotients and hazard indices. The information will be presented for each chemical and radionuclide, each pathway, each set of exposures, and each receptor. In turn, these risk values will be compared to risk thresholds. Thus, various comparisons will provide information in order to better understand and make decisions about the protection of human health.

The ecological risk assessment includes the same fundamental steps as the human health risk assessment, although the first step is called problem formulation instead of data evaluation. As described above for the human health risk assessment, these four steps follow a logical order, with additional methodical substeps. Just as is the case for human health risk methods and data, the methods and the data for the ecological risk assessment have been specified by regulatory agencies such as the Washington State Department of Ecology and the US Environmental Protection Agency. As in the case of human health, where Hanford Site-specific human receptors are being evaluated, Hanford Site-specific vegetation and animals are also being evaluated. These receptors are organized into two types according to the habitat type in which they live: (1) the land or terrestrial habitats around the WTP site, and (2) the aquatic

[1] Census Bureau. 2009. "Washington QuickLinks, Annual Estimates of the Resident Population for Incorporated Places in Washington", listed alphabetically: April 1, 2000 to July 1, 2008, release date July 1, 2009, US Census Bureau, Systems Support Division. Available at http://quickfacts.census.gov/qfd/states/53000lk.html.

habitats of the Columbia River. For the terrestrial habitats, the following receptors will be used to quantify potential risk: plants, soil invertebrates, herbivorous mammals and birds, omnivorous mammals and birds, and carnivorous mammals and birds. For the Columbia River, the following aquatic receptors will be used: plants, sediment-dwelling invertebrates, fish (including salmon) and other aquatic organisms, herbivorous waterfowl, shorebirds, and fish-eating mammals and birds. There is abundant information about the feeding habits of these organisms; there is also considerable toxicity data. A quantitative characterization will be provided for a variety of chemicals and radionuclides, assessing many pathways in a variety of geographical places and many exposures to a variety of ecological receptors. The ecological risk assessment calculates exposure and effects ratios. These ratios, called hazard quotients and hazard indices, are in turn compared to thresholds. This information will assist users in making informed decisions about the protection of the environment.

Various types and degrees of uncertainty are introduced into the human health and ecological risk assessments at every step of the process. This uncertainty occurs because risk assessment is a complex process, requiring integration of source information, estimates of fate and transport in variable environments, exposure assessment, and effects assessment. Uncertainty is inherent even when the most accurate, up-to-date, and appropriate models are used. Throughout the risk assessments, an effort is made to overestimate, rather than underestimate, the exposures and risks in order to compensate for these uncertainties. The work plan explains how an uncertainty assessment will be used to place the risk estimates in proper perspective to allow informed risk management decisions.

In summary, chemical and radionuclide contaminants present in underground tanks at the Hanford Site need to be retrieved and treated before they leak into the nearby soil and groundwater, and possibly into the Columbia River. The WTP processes to pretreat and vitrify the contents of underground tanks will help to solve this potential problem. Emissions are expected from these waste treatment processes, and this work plan shows the models and scientific data that will be used to characterize how separate chemicals and radionuclides may move through the air, soil, surface water, sediment, and food chains around the WTP in the Hanford Site environment. These airborne releases could potentially expose a variety of human and ecological receptors to chemicals and radionuclides.

This work plan will benefit from inputs from regulatory agencies, American Indian tribes, and the public. After inputs are incorporated, the work plan methods and data will be implemented. Computations will follow, and risk predictions will be compared to appropriate thresholds. These findings will be put into proper perspective using an uncertainty assessment to allow fully informed risk management decisions. These decisions will focus on protecting human health, plants, and animals while operating the WTP successfully.

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1 Introduction

This risk assessment work plan (RAWP) presents the risk assessment protocol for evaluating potential risks to human health and ecological resources from the Hanford Tank Waste Treatment and Immobilization Plant (WTP) at the Hanford Site. This RAWP is required to satisfy, in part, requirements established by condition III.10.C.11 of the WTP Dangerous Waste Permit (WA7890008967, herein referred to as the DWP), as well as addressing provisions in Washington Administrative Code (WAC) 173-303-680 and applicable Code of Federal Regulations (CFR) incorporated by reference.

The Hanford Site is located in southeastern Washington State, is owned by the US government, and is managed by the US Department of Energy (DOE), US Bureau of Land Management (BLM), US Fish and Wildlife Service (FWS), and Washington State Department of Fish and Wildlife. The WTP will include two waste vitrification facilities and a pretreatment facility, and will be built in the 200 East Area of the Hanford Site.

This work plan establishes the methods for conducting the screening-level risk assessment (SLRA) to estimate potential risks to human health and ecological resources associated with airborne releases resulting from processing Hanford tank waste into a stable, glassified form. Airborne releases are the only viable pathway for receptor exposure; therefore, the US Environmental Protection Agency (EPA) guidance for airborne releases is being used (see Section 2). Other releases, such as releases to water and non-dangerous solid waste disposal, are permitted through appropriate regulatory programs. Throughout the risk assessment process, the intent is to provide data to help assess the potential impacts to people living or working on or near the Hanford Site as well as for plants and animals.

The risk assessment, in conjunction with the other portions of the DWP will serve to:

- Establish operating conditions for the facilities
- Identify feed constituents that need to be controlled to stay below acceptable risk thresholds
- Identify monitoring of WTP components required to verify permit compliance

The limits and monitoring requirements established as a result of the risk assessment process are not the only inputs required for control and operation of the WTP. Other inputs will include the following:

- Equipment control limits and monitoring established as a result of experience with operations from similar DOE vitrification facilities, including the West Valley Demonstration Project in West Valley, New York, and the Defense Waste Processing Facility at the Savannah River Site in Aiken, South Carolina
- Control limits and monitoring recommendations of equipment vendors
- Control limits and monitoring required by other permits, approvals, and authorizations (e.g., air permits)

This RAWP contains a brief statement of the risk assessment approach (see Section 2) and a description of the WTP (see Section 3). Sections 4 through 8 present the key components of the human health and ecological SLRA protocol, as noted below:

- Section 4: Identification of constituents of potential concern
- Section 5: Quantification of airborne emissions
- Section 6: Modeling of the airborne emissions and other environmental pathways
- Section 7: Screening human health risk assessment
- Section 8: Screening ecological risk assessment

Section 9 presents the relationship of the risk assessment to the WTP, including the process to establish risk-based emissions limits, if needed. Section 10 describes how uncertainty will be handled in the SLRA. References are provided in Section 11 and are followed by four supplemental reports providing details of the constituents of potential concern (Supplement 1), details of the emissions estimate (Supplement 2), details of the WTP process cell emissions (Supplement 3), and chemical-specific physical/chemical and toxicity data for human health and ecological resources (Supplement 4). The fifth supplement (Supplement 5) provides information on air dispersion modeling. The public, American Indian tribes, and regulatory agencies are being invited to comment on this work plan and on subsequent documents to obtain their input to the decision-making process.

1.1 References

WAC 173-303-680. *Miscellaneous units*, Washington Administrative Code, effective 01 January 2005.

WA7890008967. *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste, Part III, Operating Unit 10, (Waste Treatment and Immobilization Plant).*

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2 Risk Assessment Approach

This section describes the overall SLRA scope and approach (shown in Figure 2-1) that will be used to establish operating conditions for cold commissioning (nonradioactive waste testing), as well as processing of mixed wastes at the WTP.

The primary regulatory guidance followed for this risk assessment is found in the *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (EPA 2005) and the *Screening-Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (EPA 1999).

2.1 Scope of the Screening-Level Risk Assessment

The SLRA will evaluate exposure and risks to potential human and ecological receptors within a 50-km radius of the WTP. Section 7 includes additional discussion of the human receptors, and Section 8 provides additional details of the ecological receptors.

The area within the 50-km radius of the WTP is located predominantly within Benton County in Washington State, with smaller portions located in Franklin, Grant, Yakima, and Kittitas counties. The Tri-Cities (i.e., the combined cities of Richland, Kennewick, and Pasco) are adjacent to the southern edge of the Hanford Site. The Tri-Cities area contains a population of approximately 220,000 (US Census 2009), the majority of which reside between 30 km and 50 km from the WTP site. The population outside the Tri-Cities, but within 50 km of the WTP site, is sparse. There are no permanent residences on the Hanford Site. American Indian tribes have treaty rights to resources on the Hanford Site, and the SLRA includes potential risks from food gathering and other tribal-specific activities, as well as from inhalation and external exposures to WTP emissions (for more information, see Section 7.1).

A variety of ecological receptors inhabit the Hanford Site. They include terrestrial and aquatic plants; terrestrial, aquatic, and sediment-dwelling invertebrates; mammals and birds that eat terrestrial plants and animals; fish and other aquatic biota; and mammals and birds that eat fish and other aquatic biota. These ecological receptors are discussed in more detail in Section 8.1.

The SLRA (specifically, the pre-demonstration test risk assessment [PRA] and the final risk assessment [FRA]) will address the potential operating life of the WTP. The current WTP DWP (WA7890008967) covers projected operations of the WTP. The SLRA assumes that the facility will operate at maximum capacity for its entire design life (40 years from the start of the facility operations). Risks from the waste in the Hanford double-shell tank system, as well as cumulative risks from the Hanford Site, are outside the scope of the SLRA.

2.2 Screening-Level Risk Assessment Process

The major components of the SLRA process for airborne emissions are as follows (Figure 2-1):

- **Work plan for the SLRA** – This work plan is submitted to comply with conditions of the DWP. The work plan establishes the methods for the future implementation of the SLRA. The PRA and FRA are subparts of the SLRA, as described in this work plan.

- **Pre-demonstration test risk assessment** – The PRA will be performed before performance-demonstration testing of the WTP. The PRA will estimate human health and ecological risk based on engineering estimates of emissions from WTP units.
- **Final risk assessment** – The FRA will be conducted following collection of data from performance demonstration testing of WTP units. The FRA is conducted using an approach similar to the PRA. However, estimated emission rates will be supplemented with the results of the environmental performance demonstration tests.

Participants in the SLRA process are:

- DOE
- Washington State Department of Ecology (Ecology)
- EPA, Region 10
- Yakima Indian Nation (YN)
- Confederated Tribes of the Umatilla Indian Reservation (CTUIR)
- Nez Perce Tribe
- Hanford Advisory Board (HAB)
- The general public
- Bechtel National, Inc.

All participants are welcome to make contributions to the development of this work plan.

The SLRA must serve several purposes, including (1) identifying any potential risks to human health or ecological resources that may result from emissions from the WTP; (2) providing the information necessary to determine what, if any, additional permit conditions are necessary for the operation of the WTP to be protective of human health and ecological resources; and (3) providing risk information to Ecology, EPA, DOE, American Indian tribes, and the public. For these reasons, the overall approach for the SLRA is to identify potential risks associated with both plausible and worst-case scenarios as defined in the following:

- The plausible exposure scenarios represent more realistic assumptions regarding the location of potential human and ecological receptors. The exposure scenarios reflect anticipated WTP operations and the continuation of current uses of the surrounding land and habitats, and make reasonable assumptions about future land uses while still using upper-bound estimates of exposure pathways and activity patterns.
- The worst-case exposure scenarios represent worst-case assumptions regarding the location of human and ecological receptors, exposure pathways, and activity patterns (e.g., subsistence fishing). The receptor locations used in the worst-case scenario are considered hypothetical, because assumed activities (e.g., residence, subsistence farming) do not currently occur in the worst-case Hanford Site locations nor are they expected. These hypothetical worst-case scenarios are discussed in the uncertainty assessment (Section 10).

The exposure scenarios are intended to provide a better understanding of the range of potential risks to a variety of human and ecological receptors representing conservative exposures at locations typical of the Hanford Site area under a variety of land use conditions, both now and in the future.

Both the plausible and worst-case exposure scenarios will incorporate conservative assumptions regarding human and ecological exposures. This approach is consistent with the *EPA Risk Characterization Program* (EPA 1995), which directs the "use of several descriptors, rather than a single description, to enable the EPA to present a fuller picture of risk that corresponds to the range of different exposure conditions encountered by various individuals and populations."

The general technical process for the SLRA is provided in Figure 2-2. This process starts with the estimation of air concentration of various chemicals and radionuclides, moves to an estimation of airborne deposition, and continues to predictions of movement in soil, surface water, and food. Next, exposure to humans, plants, and animals will be estimated to complete the risk characterization.

Requirements and assumptions for the FRA will be influenced by the results of the PRA, as well as from data collected during environmental performance demonstration tests. The FRA will include estimated emissions based on engineering calculations (pretreatment system emissions and vapor-phase organic emissions from WTP process cells) and environmental performance demonstration tests for the low-activity waste (LAW) and high-level waste (HLW) vitrification systems. Based on the results of the environmental performance demonstration tests, the FRA may involve running new models, modeling additional chemicals, or changing model parameters. Information that will require updating in the FRA, as specified in the DWP, will include:

- Toxicity data current at the time of the submittal
- Compounds newly identified, or updated emissions-data from current waste characterization and emission testing
- Air modeling updated to include stack-gas parameters based on most current emissions testing and current WTP unit design
- Physical/transport properties of constituents current at the time of the submittal
- Process description based on current WTP unit design
- Emissions data and all supporting calculations based on current WTP unit design
- Update of receptor locations based on land use or land use zoning changes, if any

The performance demonstration testing of melter units presents unique challenges that differ from incineration-type combustion units, which are used as a starting point for developing test plans. Comparisons are made between the systems used to control melter emissions and those used for flame combustion units, as well as comparisons to the quantities and concentrations of constituents of potential concern (COPC) fed to melter units to those of other, flame-type combustion units. For the performance demonstration test to be predictive of the melter-offgas system's ability to control emissions and demonstrate that human health and environmental protection standards established by the SLRA are met, it will be necessary to take these differences into account.

The SLRA process is iterative. It includes review of the PRA findings and revision of risk assessment assumptions, WTP engineering design, and operation of the FRA. Results of the PRA and FRA will be used to confirm that the emissions from WTP do not pose an unacceptable risk to human health or the environment. If unacceptable risks are identified, they can be mitigated through operating limits. Input from Ecology, EPA, American Indian tribes, and the public will be included at each step of the process. The graphic description of the process provided in Figure 2-1 identifies points for this input.

The PRA modeling results will be used to formulate FRA approaches; thus, the PRA is an important first step and the primary emphasis of this work plan.

2.3 References

Census Bureau. 2009. "Washington QuickLinks, Population Estimates: Places in Washington listed alphabetically: Population Estimates for July 1, 2008", release date July 1, 2009, US Census Bureau, Systems Support Division, accessed January 6, 2010. Available at http://quickfacts.census.gov/qfd/states/53000lk.html.

EPA. 1995. *EPA Risk Characterization Program,* memorandum from Carol Browner, Administrator, to EPA staff, Office of the Administrator, 21 March 1995. US Environmental Protection Agency, Washington, DC.

EPA. 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities,* Peer Review Draft, EPA 530-D-99-001A. Office of Solid Waste and Emergency Response, US Environmental Protection Agency, Washington, DC.

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WA7890008967. *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste, Part III, Operating Unit 10, (Waste Treatment and Immobilization Plant).*

1 **Figure 2-1 Overview of Screening-Level Risk Assessment Process for WTP Air Emissions**

2

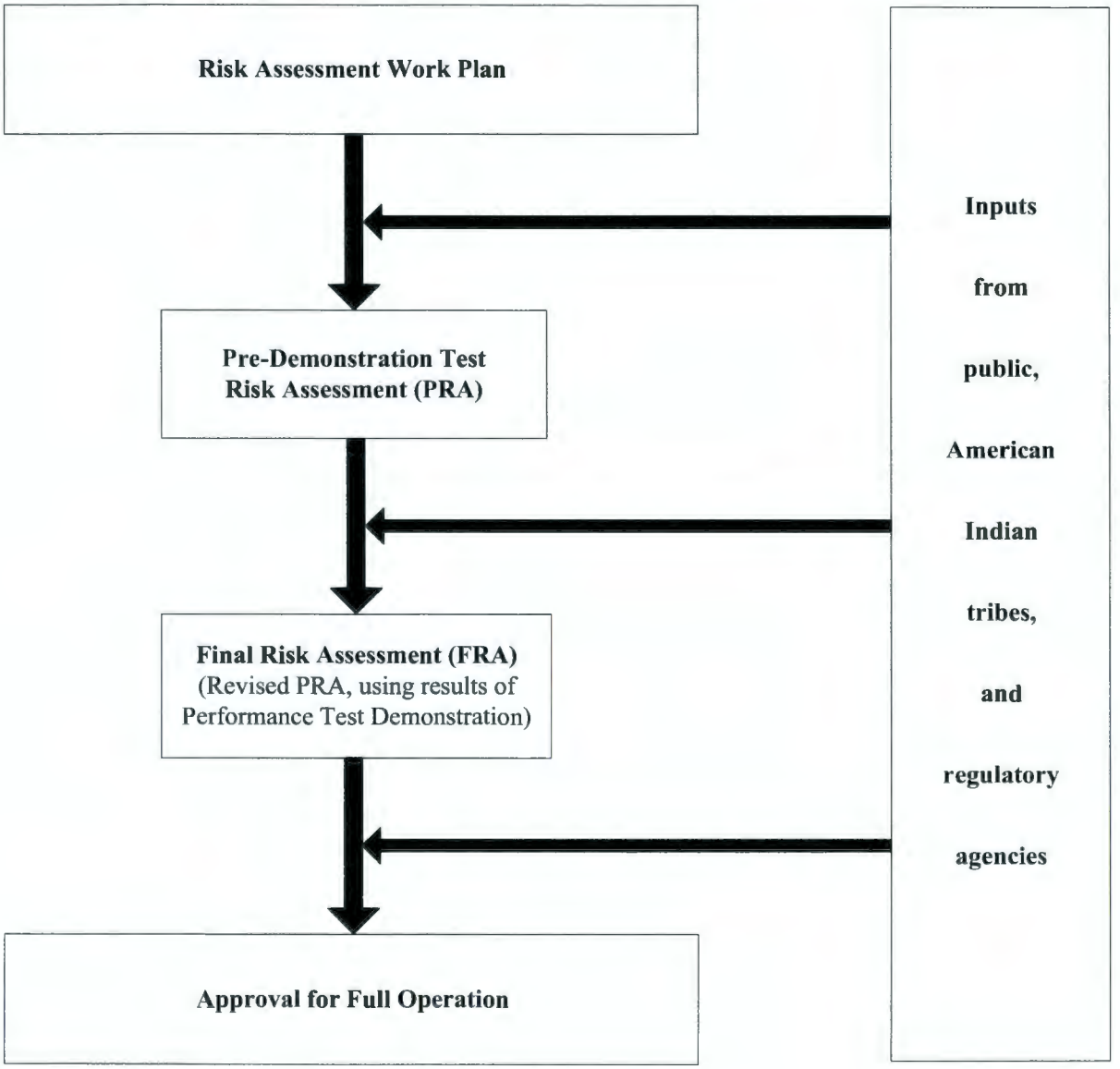

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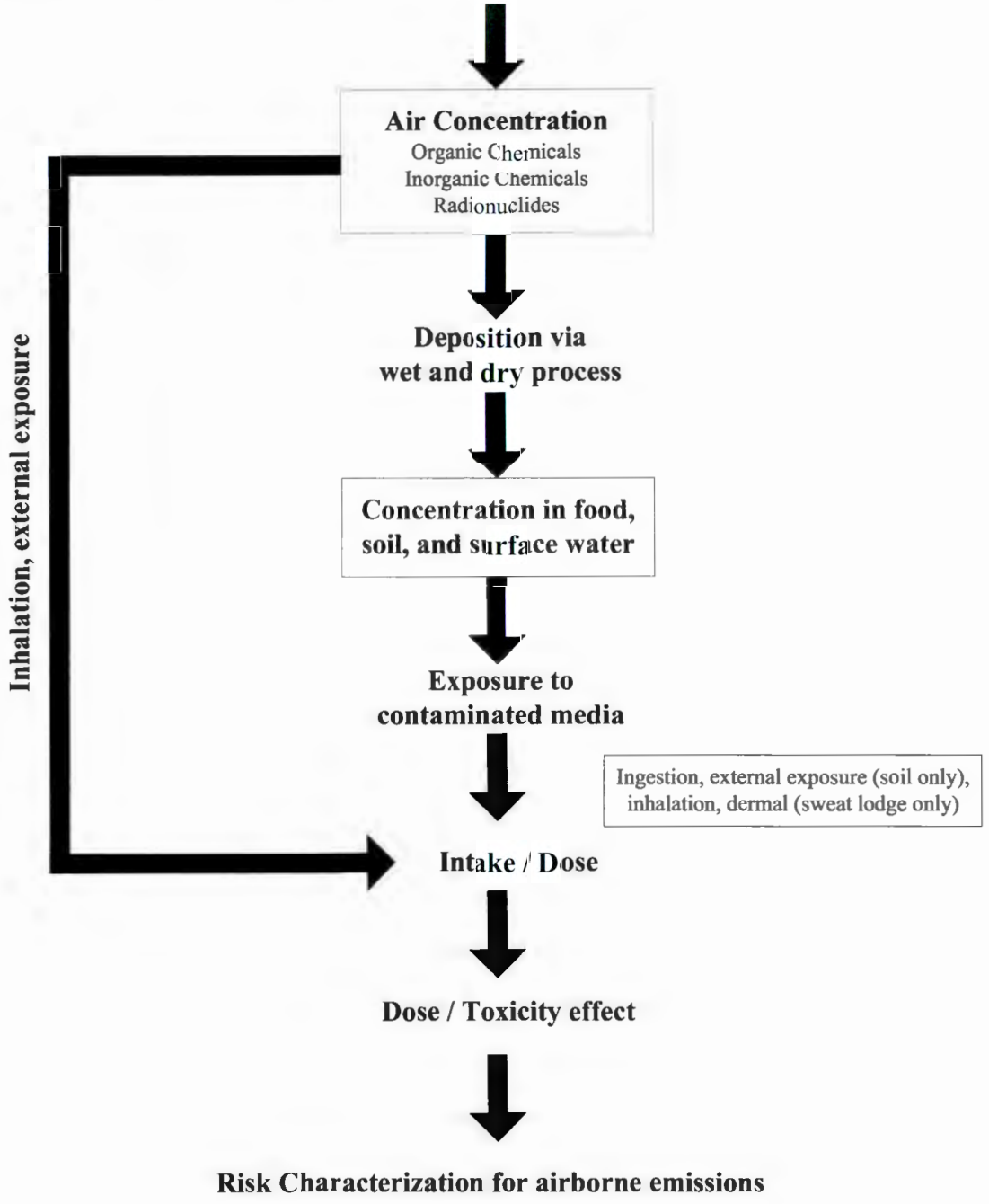
Figure 2-2 Overview of Fate and Transport of Airborne Emissions During the PRA and FRA for the WTP



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3 WTP Facility/Process Description

Hanford tank waste consists of approximately 54 million US gallons of highly radioactive and mixed hazardous wastes stored in underground storage tanks at DOE's Hanford Site. The WTP is being constructed to treat mixed wastes from underground storage tanks. After the tank waste is received from the Hanford double-shell tank system, it will be pretreated and then immobilized using a process called *vitrification*. Vitrification is a thermal process that converts the waste materials into a durable glass. The vitrified wastes and secondary wastes resulting from the WTP processes will be transferred to permitted treatment, storage, or disposal units for disposition. Offgas generated by the pretreatment and vitrification processes will be treated in independent offgas treatment systems. This section provides an overview of the mixed waste treatment processes that will be used in the WTP. Readers should consult Chapter 4 of the Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Part III, Operating Unit Group 10, (permit number WA7890008967) for additional details on WTP engineering and waste treatment processes.

3.1 WTP Overview

The WTP is located at the eastern end of the 200 East Area of the Hanford Site, near the former Grout Treatment Facility, 241-AP Tank Farm Complex, and Plutonium Uranium Extraction Plant. Figure 3-1 shows the location of the WTP on the Hanford Site.

Waste from the Hanford double-shell tank system will be transferred to the WTP Pretreatment (PT) Facility. The tank waste consists of solids (sludge), liquids (supernatant), and saltcake (dried salts that will dissolve in water to form supernatant).

The term low-activity waste (LAW) feed generally refers to the supernatant portion of Hanford's double-shell tank waste, although it can include high-level waste (HLW) solids. Hanford tank waste is from a variety of nuclear process facility sources. It historically has been managed as HLW. Since the Hanford project began, different chemical processes have been used to separate plutonium from spent fuel and targets received from many different nuclear reactors. Many waste components were added to the tanks or blended together as part of an in-tank process. In addition, some of the wastes were later reprocessed, resulting in significant blending of the wastes. Evaporators were used to reduce the waste volume. Waste was also left in a waste tank at high temperature which impacts the minerals that formed from these wastes (Agnew and others 1997).

As a result of these previous waste processing activities, the tanks are filled with millions of gallons of waste as sludge, saltcake, and aqueous supernatant. Most of the saltcakes' contents are expected to be dissolved when the waste delivery processing occurs in the tank farms to prepare the waste for sluicing to WTP (Kirkbride and others 2007). The sludges consist primarily of oxides, hydroxides, or silicates of Al, Fe, Cr, Bi, Ni, U, Cd, Zr, and many more trace species and radionuclides (24590-101-TSA-W000-0004-114-00021). The supernatants are primarily sodium salts of NO_3^-, NO_2^-, OH^-, CO_3^{-2}, $Al(OH)_4^-$, PO_4^{-3}, SO_4^{-2}, F^-, Cl^-, CrO_4^{-2}, along with potassium and other trace species (Kirkbride and others 2007). Both sludge and saltcake contain large amounts of oxalate ($C_2O_4^{-2}$) and many other organics, including solvents and chelates (24590-WTP-RPT-RT-07-002).

A recent study investigated the feed composition estimate (called a feed vector) and grouped the feeds into 13 groups based on which element or elements in the feed, after WTP pretreatment, will limit the

waste concentration in immobilized HLW (IHLW) glass (24590-WTP-RPT-PE-07-001). The 13 groups are named as follows:

aluminum low-leach	iron-aluminum	calcium
aluminum high-leach	phosphate	uranium
chromium	iron	sulfate
bismuth	zirconium-aluminum	
fluoride	sodium	

In addition to these 13 groups, there is the LAW group, with low undissolved solids concentration, and the lead (Pb) group, that were impacting a single feed batch (24590-WTP-RPT-PE-07-001).

Figure 3-2 shows a layout of the WTP. Three main process buildings (PT Facility, HLW Facility, and LAW Facility) will contain most of the dangerous waste management operations and include major areas for pretreating and vitrifying (immobilizing) tank waste. The PT Facility will receive and pretreat the waste before vitrification. Two separate vitrification facilities will be used to immobilize the pretreated waste. The LAW Facility will immobilize the majority of the supernatant and dissolved saltcake from the Hanford tank waste. The HLW Facility will immobilize the HLW fraction of the Hanford tank waste. Other smaller support buildings will provide for storage or transfer of materials used in the treatment process and for storage of wastes.

Figure 3-3 provides a simplified diagram of the WTP processes. Mixed wastes from the double-shell tank system (shown in the lower left corner of the diagram) will be received and processed through the various WTP pretreatment operations (including feed evaporation, ultrafiltration, and ion exchange). The resultant pretreated wastes will, in turn, be fed to the LAW or HLW vitrification systems. The treatment of offgas from the pretreatment and vitrification processes will result in point-source emissions to the environment from each of the three processing facility stacks. In actuality, each facility stack is a bundle of individual flues (or pipes) from that facility that are supported together inside a structural steel lattice (see Figure 3-4). The individual flues separately exhaust process and building ventilation from the facility. Figure 3-5 depicts the process flues that correspond to each of the three main process buildings. For example, the PT Facility has flues that exhaust the process and vessel ventilation system, the reverse flow diverter/pulse jet mixer system, and the process cell emissions. Additional nonprocess-related flues are not shown on Figure 3-5 because they do not contribute COPCs or radionuclides of potential concern (ROPC) emissions to the environment. The nonprocess flues do, however, influence contaminant dispersion profiles by virtue of their effect upon parameters important to air dispersion modeling (e.g., gas flow rate, velocity, and temperature). Flue parameters relevant to air dispersion modeling are presented in *Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol* (24590-WTP-RPT-ENV-08-001), Supplement 5 of this document.

3.2 Pretreatment Overview

The LAW supernatant will be transferred to the WTP PT Facility as solutions that contain some undissolved solids (HLW waste or LAW-precipitated salts). The HLW feed will be transferred as slurry to the WTP PT Facility.

Wastes having sodium molarity less than 5 will be received into the PT Facility and concentrated in the waste feed evaporator. Wastes having a sodium molarity greater than or equal to 5 will bypass the waste feed evaporator. Once the sodium molarity is acceptable for further processing (either as-received or after evaporation), the waste will go through the following processes:

- LAW feeds will be blended with HLW feeds in an ultrafilter preparation tank. The ratio of LAW to HLW undissolved solids will be established to support the respective glass production rates. The blended HLW and LAW feed streams will undergo a filtration process that separates LAW liquid stream (permeate) from the slurry. The LAW permeate will then be processed through the ion exchange (IX) process discussed below. The concentrated solids slurry will be caustic leached (if warranted), washed, and blended with cesium concentrate from the IX and strontium/transuranic (TRU) solids from ^{90}Sr/TRU precipitation (see below), before being transferred to the HLW Facility.
- Some feeds will contain organic complexants that cause the Sr and some TRU waste to remain in solution. This waste will undergo a ^{90}Sr/TRU precipitation process before filtration. The filtration step will then separate the ^{90}Sr/TRU solids, manganese oxide solids (a by-product from the precipitation process), and entrained solids from permeate (LAW stream). The ^{90}Sr/TRU precipitate will be washed and stored for blending with HLW feed before HLW vitrification. The ^{90}Sr/TRU precipitate (solids) will not be caustic leached. Filtration permeates are processed through the IX processes.
- After filtration, the permeate will undergo IX to remove ^{137}Cs. The ^{137}Cs eluate will be concentrated by evaporation; the concentrated eluate will then be blended with pretreated HLW solids before transfer to the HLW Facility. The last step in the pretreatment process is to concentrate the treated LAW liquid by evaporation before transferring the waste to the LAW Facility.

The PT Facility will also contain an offgas treatment system designed to abate emissions from the pretreatment processes. The offgas treatment system consists of several control devices:

- Caustic scrubber
- High-efficiency mist eliminators (HEME)
- Primary high-efficiency particulate air (HEPA) Filters
- Secondary HEPA filters
- Thermal catalytic oxidizer unit
- After-cooler
- Carbon bed adsorbers
- Adsorber outlet filter
- Demisters
- Electric heaters
- Primary HEPA filters
- Secondary HEPA filters
- Exhaust fans
- Stacks/exhaust flues

See the DWP, Chapter 4 for details.

Liquid effluents will be either recycled back into the facility or sent to the Hanford Site Liquid Effluent Retention Facility or 200 Area Effluent Treatment Facility.

3.3 LAW Vitrification

Treated supernatants from the PT Facility will be transferred to the LAW Facility for processing. The LAW vitrification process will consist of two melter systems operated in parallel. Each melter system has a set of feed preparation vessels, a large-capacity joule-heated ceramic melter, and an offgas treatment system. The facility will also have a secondary offgas system shared by the two melter systems. The following description applies to each of the two LAW melter systems.

Pretreated LAW waste feeds will be received into one of two LAW concentrate receipt vessels inside the LAW Facility. Batches of concentrated LAW feed will be transferred from these vessels to feed preparation vessels, where glass formers and sucrose will be added and blended to form a uniform batch of feed to the LAW melters. The slurry feed will be transferred to the melter feed vessels, where it is fed continuously to the LAW melters.

Each LAW melter is designed to nominally produce 15 metric tons per day of immobilized LAW (ILAW) glass and operate at an approximate temperature between 950 °C and 1150 °C. The feed will enter the melter from the top and form a cold cap above the melt pool. Volatile components in the feed will be evaporated or decomposed, then drawn off through the melter offgas system. Nonvolatile components will react to form oxides or other compounds dissolved in the glass matrix. Bubblers will agitate the mixture to increase the glass production rate. An airlift system will pour the glass from the melter into stainless steel containers.

The LAW melter offgas system consists of the following control devices:

- Primary and secondary film coolers, one set for each melter
- Submerged bed scrubbers (SBS)
- Wet electrostatic precipitators (WESP)
- Electric heaters
- HEPA filters
- Carbon adsorber
- Selective catalytic oxidizer
- Selective catalytic reduction (SCR) unit
- Heat exchanger
- Caustic scrubber
- Melter offgas exhausters
- Stacks/exhaust flues

Each LAW melter system will have its own primary offgas equipment, including a film cooler, SBS, and WESP. Particulates and condensables, including entrained or volatilized radionuclides in the melter offgas stream, will be captured in the SBS and WESP. Condensables from the SBS and the WESP will be collected in the liquid effluent system and recycled to the treated LAW evaporator in the pretreatment facility. The primary offgas systems will join after the WESP and will be routed to the secondary offgas system. At this point, the LAW vessel vent header will join the offgas. The secondary offgas system will provide final filtration, remove mercury, destroy organics, reduce oxides of nitrogen (NO_x), and remove

halides. This will be done by using HEPA filters, a treated activated carbon bed, a thermal catalytic oxidizer, a selective catalytic reducer, and a caustic scrubber.

See the DWP, Chapter 4 for details.

3.4 HLW Vitrification

The HLW Facility will receive the pretreated HLW feed from the PT Facility. Treated HLW slurries and the LAW intermediate waste products (separated ^{90}Sr/TRU and ^{137}Cs) will make up the feed to the HLW Facility. The HLW vitrification process will consist of two joule-heated ceramic melters fed by independent feed and blending vessel trains, a dedicated offgas treatment system for each melter, and a common secondary effluent collection system. The HLW feed concentrate will be transferred from the PT Facility to one of two melter feed preparation vessels in the HLW Facility. The feed concentrate will be blended with glass-forming chemicals and sucrose, and then mixed to ensure a uniform mixture. The melter feed slurry will be transferred to the melter feed vessel, where it will be fed to a dedicated HLW melter.

Each of the two HLW melters is designed to operate at an approximate temperature between 950 °C and 1150 °C at nominal rates of 3.0 to 3.75 metric tons per day of IHLW glass. Melter feed slurry will be introduced at the top of the melter and form a cold cap on the surface of the melt pool. Water and volatile components will evaporate or decompose and then be drawn off through the offgas system. Nonvolatile components will react to form oxides, which will become part of the molten glass. Bubblers will agitate the mixture to increase the glass production rate.

Each HLW melter will have dedicated primary and secondary offgas systems where the offgas from the melter will pass through a film cooler, SBS, WESP, HEMEs, and HEPA filters to remove particulates and radionuclides. The offgas will then pass through a secondary offgas system consisting of treated activated carbon, silver mordenite, thermal catalytic oxidation, and SCR. This secondary system will remove mercury and halides, destroy organics, and reduce NO_x.

An airlift system inside the melter will pour molten HLW glass into stainless steel canisters. The filled canister will then be inspected, the glass sampled if necessary, and the canister sealed. The canisters from the two melters will be decontaminated by a nitric acid/cerium (HNO_3/Ce^{+4}) chemical milling process that dissolves a thin layer of the canister outer wall material. Canister decontamination waste effluents will be recycled to the PT Facility.

The purpose of the HLW primary offgas treatment system is to cool the melter offgas and to remove offgas aerosols and particulates generated by the melter and from the vessel ventilation air. This treatment system consists of the following:

- Film coolers
- SBSs
- SBS condensate receiver vessels
- WESPs
- HEMEs
- Electric heaters
- HEPA filters

- Activated-carbon columns
- Silver-mordenite columns
- Thermal catalytic organic oxidizers
- NO_x SCR units
- Heat exchangers
- Booster fans
- Stack fans
- Stacks/exhaust flues

See the DWP, Chapter 4 for details.

3.5 Stacks and Flues

The PT, LAW, and HLW Facilities will each have separate stacks from which the treated emissions derived from process operations and other sources will be released to the environment. The stacks will house a bundle of individual emission units (flues) that are associated with their respective sources. Thus, each of the three facilities will have one stack only. Additional information regarding the individual flues and their corresponding offgas parameters (e.g., flow rate, velocity, and temperature) is included in Supplement 5.

In addition to the process offgas system, building ventilation systems will be incorporated into each of the processing plants. Treated building ventilation systems will also be vented to the atmosphere through dedicated flues. Figure 3-5 presents a simplified graphic of the expected emission sources and the associated flues. Those flues whose emissions are estimated using the steady-state flowsheet model also include the unique stream identifiers (e.g., HOP-31) that are shown in Figure 3-3 and discussed further in Supplement 2.

The offgases associated with pretreatment processes will be exhausted through the PT Facility stack via flues PT-S3 and PT-S4. Flue PT-S3 is used to discharge the PT offgas and vessel ventilation emissions, and PT-S4 is used to discharge PT pulse jet ventilation emissions. The emissions associated with potential leaks to processing cells will be discharged through a third flue within the PT stack identified as PT-S2. The treated offgases associated with LAW vitrification processes will be discharged through the LAW vitrification stack via flue LV-S3. The emissions associated with leaks to the LAW vitrification process cells will be discharged through flue LV-S2. The treated offgases associated with the two HLW melter offgas streams will be discharged through the HLW Facility stack through flues HV-S3a and HV-S3b, and the HLW pulse jet ventilation offgas stream will be discharged through flue HV-S4. The emissions associated with potential leaks to process cells will be discharged through the HLW Facility stack via the HV-S2 flue.

3.6 Facility Control Philosophy

This section presents an overall control philosophy for the WTP. The goal of the facility control philosophy is to satisfy the following criteria:

- Preservation of worker and public safety
- Protection of the environment

- Preservation of equipment integrity
- Assurance of product quality
- Minimization of plant lifetime costs

The design, construction, and commissioning of the WTP are being conducted in a manner that is protective of employees, the public, and the environment. The process systems, piping, vessels, and equipment have been specifically designed to provide primary confinement of hazardous, radioactive, and chemical materials. The facility structures, along with their respective ventilation systems, will provide secondary confinement of airborne and liquid releases. The ventilation system will support confinement of airborne contamination within the building by directing the flow of air from areas of less contamination potential to areas of greater contamination potential. The ventilation system will also filter the building exhaust air.

Diagnostics will be used to optimize throughput and reduce downtime. A plant information computer with data entry and reporting capabilities will be provided to process information needed for facilitating plant optimization. Provisions will be made for overview and scheduling information.

The confinement and shielding requirements, combined with the need to provide hazard isolation and accessible areas for plant operation, have led to the building configuration of multiple cells and caves connected by transfer tunnels and shielded doors. This configuration provides a series of barriers enclosing the various zones, which are classified according to the contamination potentials.

Throughout the design phase, design reviews are conducted by multidiscipline teams to ensure safety and provide for feedback and improvement. The process systems, facility structure, and facility design ensure that WTP operations will be safe and protective of human health and the environment.

3.7 References

Agnew SF, Boyer J, Corbin RA, Duran TB, Fitzpatrick JR, Jurgensen KA, Ortiz TP, and Young BL. 1997. *Hanford Tank Chemical and Radionuclide Inventories HDW Model*, LA-UR-96-3860, Rev 4. Los Alamos National Laboratory, Los Alamos, NM.

Kirkbride and others. 2007. *Tank Farm Contractor Operation and Utilization Plan*, HNF-SD-WM-SP-12, Rev 6. CH2M Hill Hanford Group Inc., Richland, WA.

WA7890008967. *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste, Part III, Operating Unit 10, (Waste Treatment and Immobilization Plant).*

24590-WTP-RPT-ENV-08-001, Rev 1, *Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol*

24590-WTP-RPT-PE-07-001, Rev 1, *WTP Waste Feed Analysis and Definition-EFRT M4 Final Report.*

24590-WTP-RPT-PT-02-005, Rev 6, *Flowsheet Bases, Assumptions, and Requirements.*

24590-WTP-RPT-RT-07-002 Rev 0, *Impact of Non-Aqueous Phase Organic Compounds in the Hanford WTP.*

24590-101-TSA-W000-0004-114-00021, Rev 00B, *Report - Estimate of Hanford Waste Insoluble Solid Particle Size and Density Distribution.*

1 **Figure 3-1 Location of the WTP on the Hanford Site**

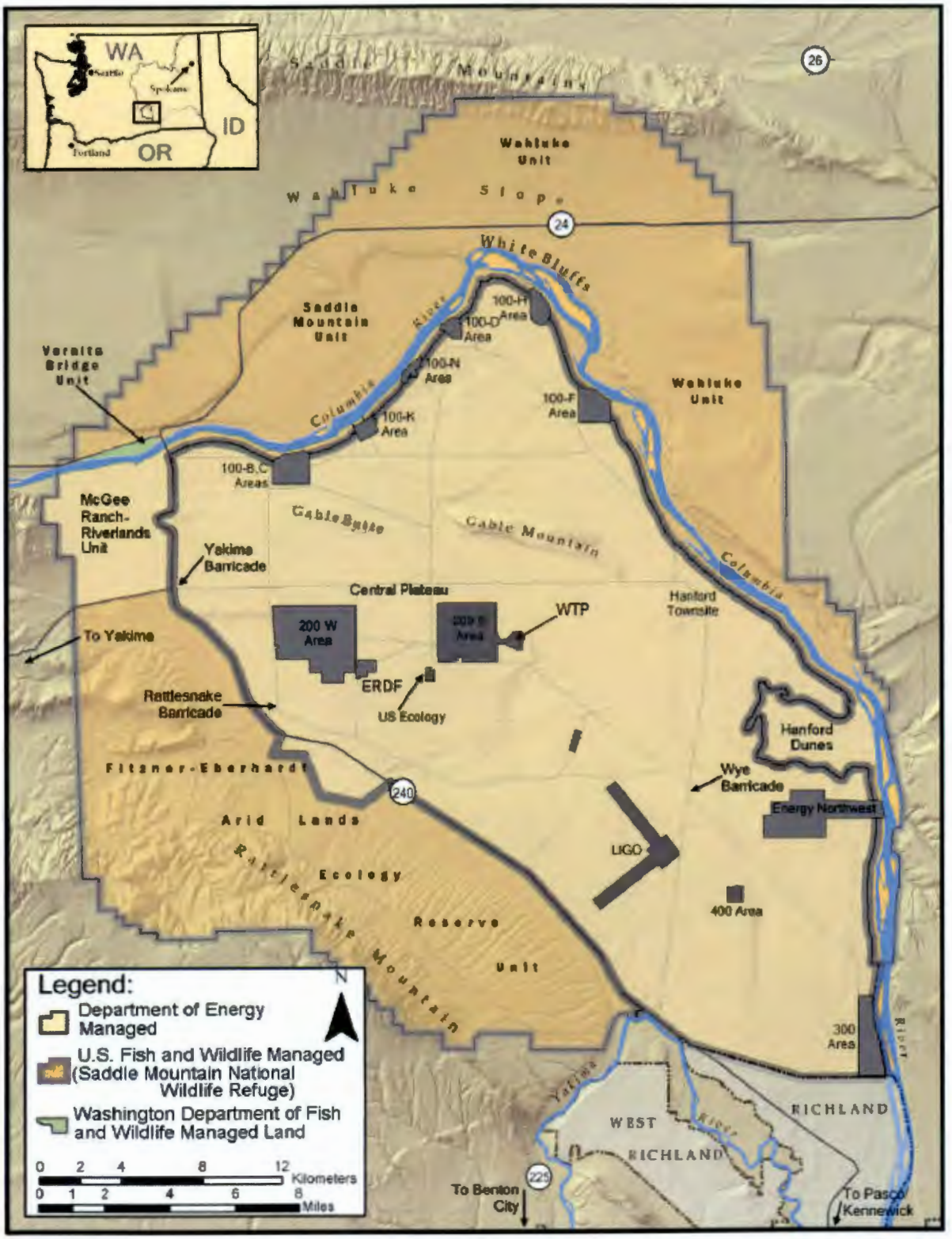

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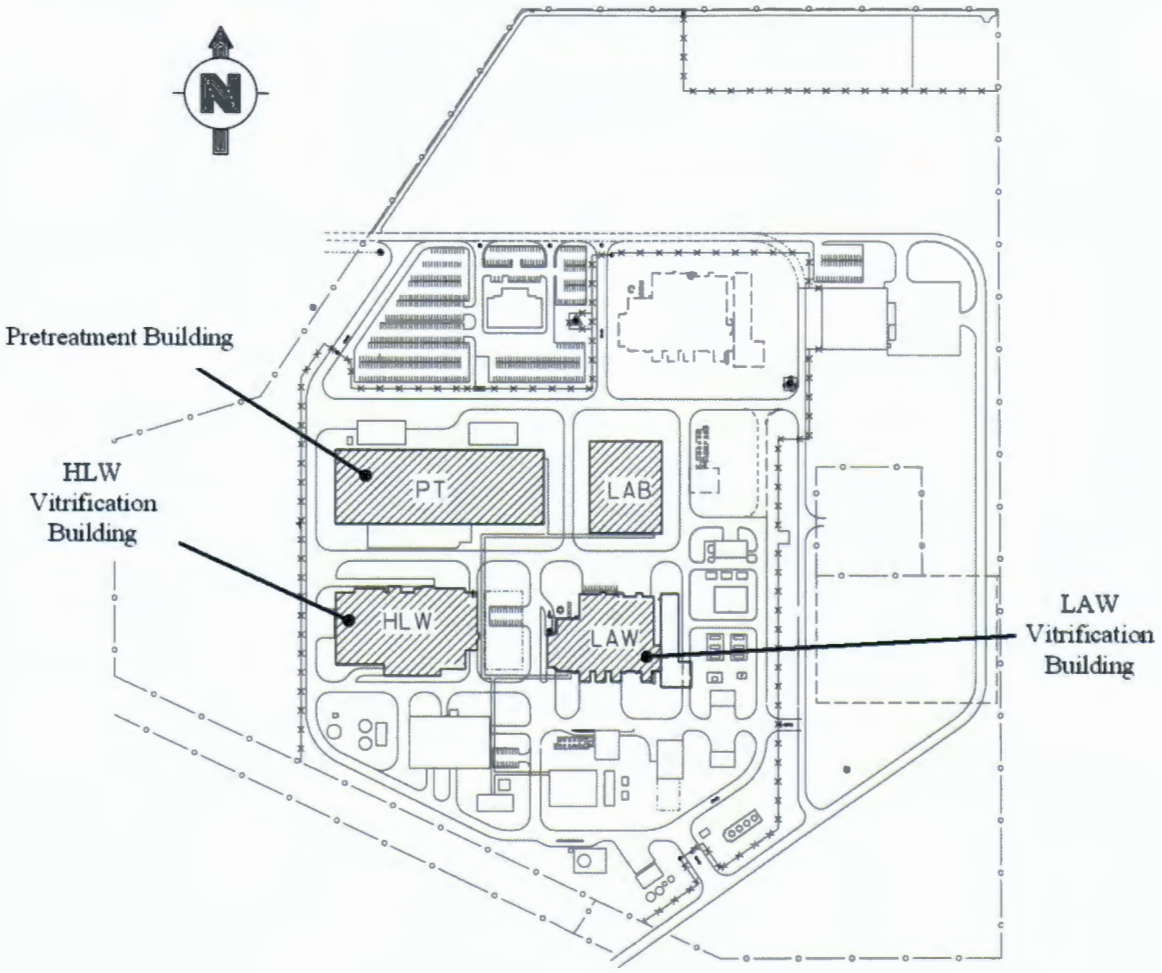
Figure 3-2 WTP Layout



1 **Figure 3-3 Simplified Process Diagram**

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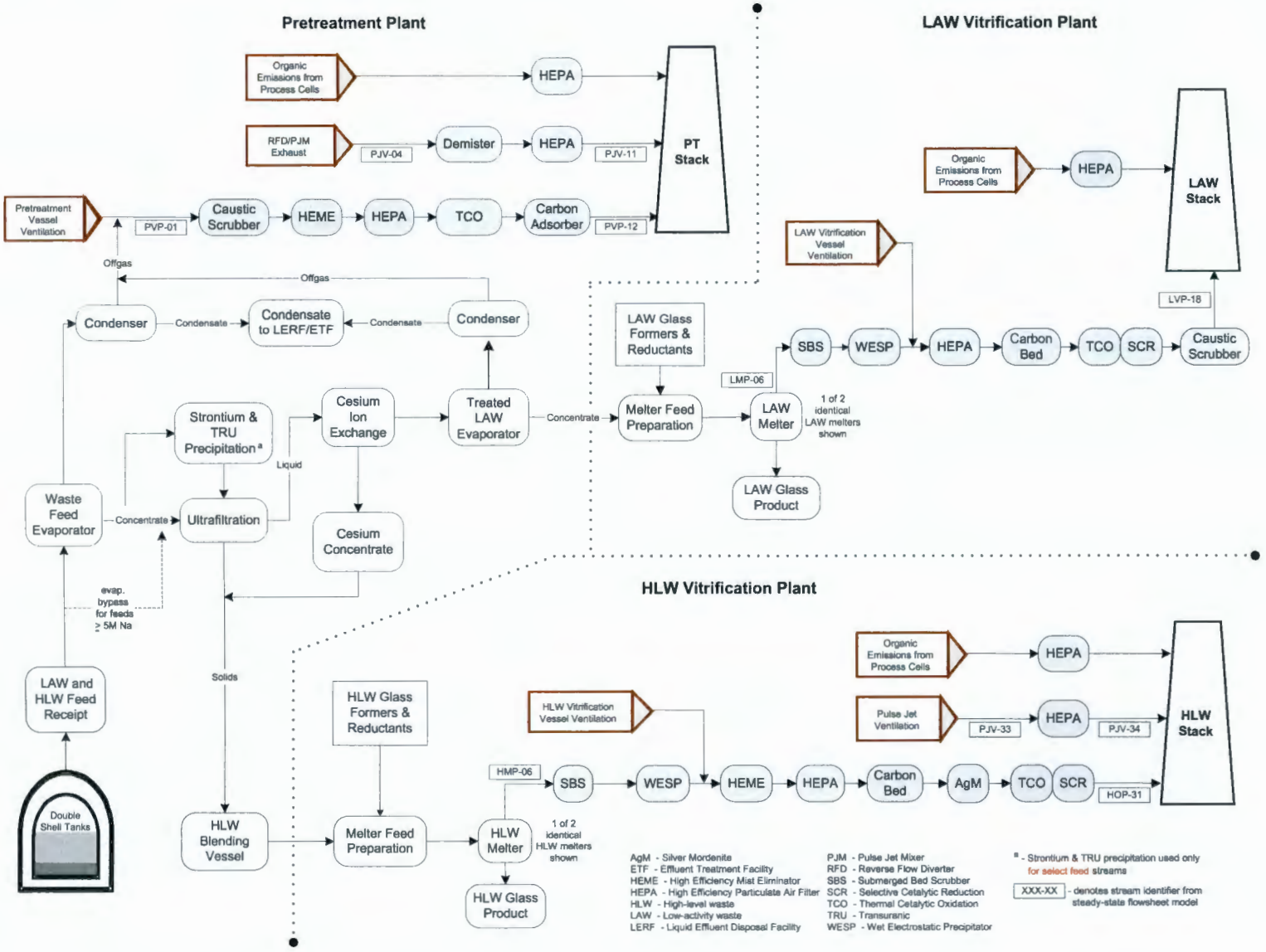
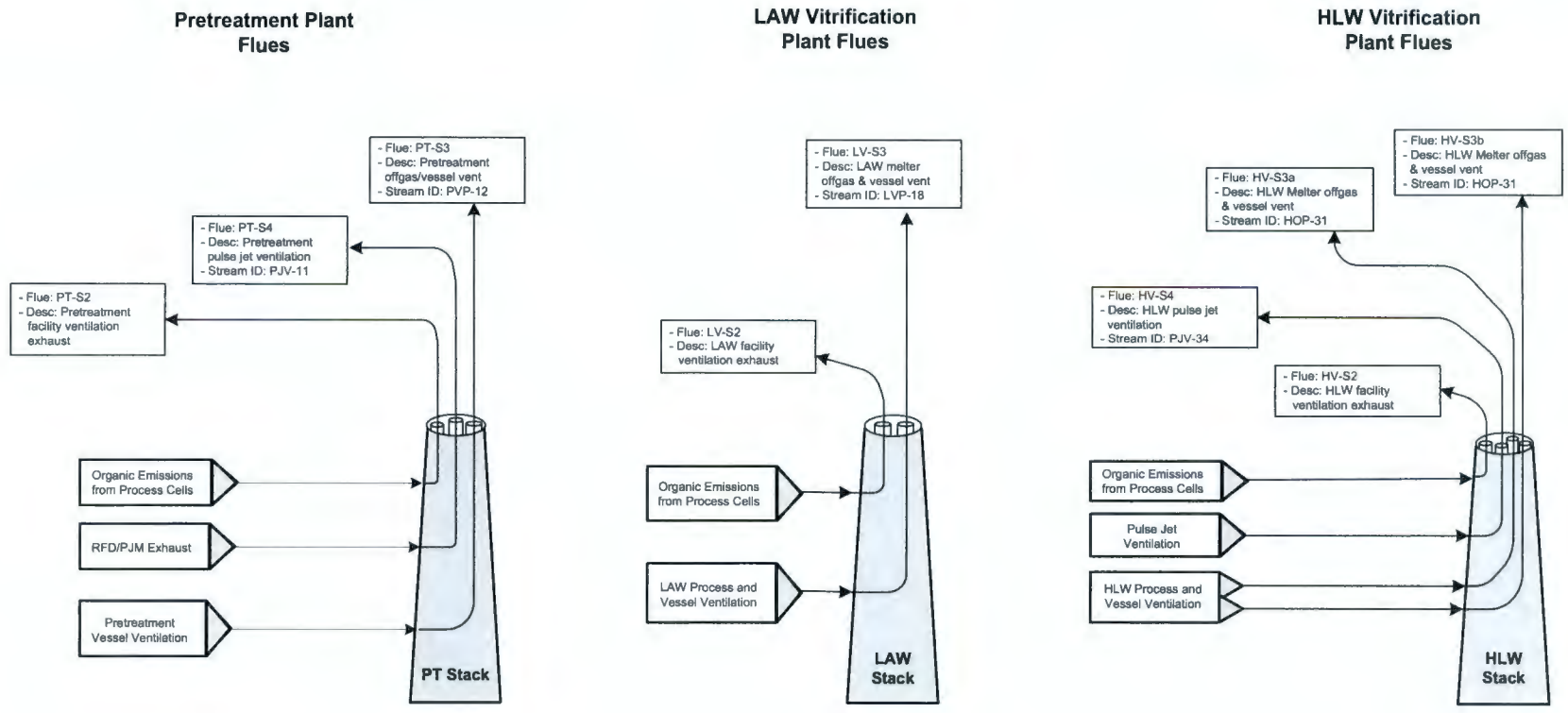


Figure 3-4 Photos of the LAW Facility Stack

The LAW Facility stack

LAW Facility flues enclosed within the stack lattice

Figure 3-5 WTP Stacks and Flues



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4 Constituents of Potential Concern

The *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (EPA 2005, herein referred to as the HHRAP) recommends that the selection of COPCs focus on compounds that (1) are likely to be emitted because of the presence of the compound or its precursors in the waste feed, (2) are potential products of incomplete combustion (PICs), (3) are potentially toxic to humans, and/or (4) have a definite propensity for bioaccumulating or bioconcentrating in human and ecological food chains. The process for identifying COPCs is described in Supplement 1.

4.1 Identification of COPCs and ROPCs for the Quantitative Pre-demonstration Test Risk Assessment

The COPCs and ROPCs identified in Supplement 1 include an extensive list of chemicals and radionuclides that are (1) potentially present in the waste to be processed or (2) potentially produced as PICs during the WTP processing of waste. The process of identifying of COPCs and ROPCs for the PRA-selected chemicals is in accordance with the recommendations in the HHRAP.

Final COPCs and ROPCs carried through the quantitative risk assessment will be all those COPCs and ROPCs for which:

- Appropriate physical/chemical parameters are available to quantitatively estimate potential emissions and fate and transport behavior of the constituent through the environment
- Appropriate human health or ecological toxicity data are available to quantitatively evaluate potential effects of the constituent

Constituents not included in the quantitative risk assessment will be discussed qualitatively as part of the uncertainty assessment.

4.1.1 Identification of Organic and Inorganic COPCs for Inclusion in the Quantitative PRA

The list of organic COPCs consists of many categories of volatile and semivolatile organic compounds. EPA (1994) has identified several categories of WTP COPCs (e.g., dioxins/furans, polycyclic aromatic hydrocarbons [PAHs], polychlorinated biphenyls [PCBs], phthalates, other chlorinated organics, and nitroaromatics) as having the highest potential to cause increased risk to human health from chronic exposure. The organic and inorganic COPCs that can be carried through the quantitative risk evaluation is identified in Supplement 4. Note the data available are continually changing. Therefore, the PRA and FRA will update this information.

This list of inorganic COPCs includes the most stable form of the 11 chemicals listed below, also evaluated as ROPCs:

antimony	nickel	uranium
barium	selenium	yttrium
cadmium	strontium	zirconium
cobalt	tin	

The PRA and FRA will evaluate the chemical toxicity (i.e., not associated with radioactivity) as well as the effect of the radioactivity for these constituents.

4.1.2 Identification of ROPCs for Inclusion in the Quantitative PRA

The preliminary ROPCs were identified per the method described in Supplement 1. Supplement 4 describes the available toxicity and physical/chemical data appropriate for evaluation of chronic human health, acute human health, and chronic ecological exposures to ROPCs.

4.2 Uncertainty in the COPC and ROPC Lists

The identification of COPCs and ROPCs for the PRA is uncertain because these constituents are identified before operation of the WTP and must, therefore, rely on assumptions regarding what may be in the waste feed and what may be produced as PICs. Because test data collected for the FRA environmental performance demonstration will be restrained by detection limits and variations in actual waste feed, the uncertainty will not be eliminated by these tests.

In both the PRA and FRA, uncertainty is introduced into the risk assessment by COPCs that cannot be carried through the quantitative assessment due to lack of toxicity data (all ROPCs have adequate toxicity data to be carried through the quantitative assessment).

The following section briefly describes the sources of uncertainty in the identification of COPCs and ROPCs for the PRA. Section 10 provides an overview of how these uncertainties will be evaluated, along with uncertainties in all other steps of the risk assessment.

4.2.1 Uncertainty in Identification of COPCs and ROPCs for PRA

Sources of uncertainty in the identification of COPCs and ROPCs include the following:

- Uncertainty in the contents of waste feed from the double-shell tanks (DST)
- Uncertainty in PICs that may be produced by the WTP, once operational

While a considerable amount of analytical data are available for the contents of the DSTs, the contents of all tanks have not been fully characterized. To compensate for deficits in the analytical data, the regulatory data quality objective (DQO) (Wiemers et. al. 1998) that was used as the basis for the COPC list incorporated constituents that could be present in the tanks, based on Hanford activities, even if those constituents have not been detected in analytical samples.

Limited PIC data are available from bench and pilot-scale tests performed on surrogate waste. This surrogate waste was designed to represent the most difficult-to-destroy chemicals potentially present in the tank waste and, thus, to provide a conservative estimate of potential PICs. To maintain a conservative bias in the PRA, PICs identified by EPA (1998) as present in stack emissions from existing hazardous waste incinerators were included in the COPC list, along with WTP-specific PICs identified in the bench-scale testing. The ROPCs are not produced as PICs.

4.2.2 Uncertainty in COPCs Not Included in the Quantitative Assessment

Some COPCs identified as potentially present in the waste or as PICs cannot be carried through the quantitative risk assessment because appropriate toxicity data are not available to characterize their potential effects on human or ecological receptors. Constituents without toxicity information will not be included in the quantitative human health or ecological risk assessments. If these constituents are similar in toxicity and persistence to the constituents with toxicity data, the total risk or hazard would be underestimated approximately proportionately. Hazards would be underestimated by a factor proportional to the number of constituents without data divided by the total number of constituents. Similarly, for ecological receptors, if the toxicity and persistence of the constituents without toxicity data are similar to the toxicity and persistence of the constituents with toxicity data, the total hazard would be underestimated proportionally, according to the percentage of constituents without ecological toxicity data. Supplement 4 contains a tally of constituents with data and identifies the kind of data available. The PRA and FRA will address the uncertainty associated with COPCs without toxicity data.

4.3 Summary of Identification of COPCs and ROPCs

The list of COPCs and ROPCs selected for the PRA includes many more compounds than are expected in actual facility emissions. The list is long because assumptions were used to compensate for the uncertainty regarding the exact makeup of the waste and the lack of environmental performance demonstration data (it was assumed that all chemicals potentially present in the waste would be emitted along with all chemicals identified as PICs from any type of combustion unit). The list of preliminary COPCs and ROPCs includes numerous chemicals (especially organic chemicals) that have never been detected in the tank waste.

Supplement 1 documents the process used to identify preliminary COPCs and ROPCs for the PRA. Supplement 4 summarizes the current availability of data to quantitatively evaluate the preliminary COPCs and ROPCs. These tables also provide a list of the COPCs and ROPCs that will be quantitatively evaluated in the PRA. The uncertainty assessment will qualitatively address preliminary COPCs and ROPCs not quantitatively addressed in the PRA.

Supplement 4 identifies the human receptor groups and exposure pathways for which risks/hazards can be quantified for each COPC and ROPC (based on the availability of physical/chemical parameters for fate and transport modeling and toxicity data for evaluating effects on human health receptors). The human receptors identified in these tables are as follows:

- Hanford site industrial worker
- Residential receptors
- Subsistence receptors
- Nursing infant
- Acute receptor

Also, Supplement 4 identifies the ecological receptors for which hazards can be quantified for each COPC and ROPC. The ecological receptors identified in these tables are as follows:

- Terrestrial plants and invertebrates
- Terrestrial mammals and birds
- Aquatic biota, salmonids, and benthic invertebrates

The COPC and ROPC lists will be reevaluated for the FRA following completion of the environmental performance demonstration tests. This reevaluation will take into account any new information gathered during the PRA and performance demonstration tests and will include input and approval by Ecology and EPA.

4.4 References

EPA. 1994. *Draft Exposure Assessment Guidance for Resource Conservation and Recovery Act Hazardous Waste Combustion Facilities: Attachment, April 15, 1994*, Table 1 – Chemicals Recommended for Identification and Table 2 – Chemicals for Potential Identification. US Environmental Protection Agency, Washington, DC.

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5 Estimation of Emissions

The WTP is being designed to pretreat and vitrify radioactive mixed waste. A bounding estimate of stack emissions from the WTP has been developed to allow for numerical quantification of the human and ecological risks associated with airborne emissions. The emissions estimate individually considers 409 organic, inorganic, and radionuclide constituents of potential concern that could result from processing Hanford tank waste through the WTP. This section provides an overview of the assumptions and methodology used to arrive at the WTP stack emission estimates.

5.1 Emissions Sources

The SLRA considers potential emissions from the following sources:

Process Emissions. Process emissions are defined as chemicals and radionuclides released from the WTP plant stacks as a result of normal (i.e., routine) operations. Emissions associated with waste processing are discussed in Section 5.2.

Process Upset Emissions. Process upset emissions are defined as chemicals and radionuclides released from the WTP stacks as a result of nonroutine operations (such as a process malfunction). Process-upset emission rates are assumed to be higher than normal process emission rates because the upset condition is assumed to result in decreased offgas treatment efficiency or increased formation of PICs. However, process-upset emissions are for a shorter duration. For the PRA, the conservative assumption that all upset conditions result in increased emission rates for short durations will be used. Process upset conditions are further described in Section 5.3.

Non-Steady State Operations Emissions. The WTP may have idle time and will have maintenance time. Changeout of HEPA filter media and replacement of catalysts are examples of maintenance activities. These non-steady-state operations are assumed to be bounded by the upset factor multipliers (see Section 5.3).

Fugitive Emissions. Fugitive emissions are defined as emissions of chemicals and radionuclides from non-stack sources. The WTP processing buildings that will manage the Hanford tank waste will be operated under negative pressure, and the air from the process buildings will be released to the atmosphere through one of the stacks or flues described in Section 3.5. Since the WTP will not have emissions that do not pass through a stack or flue, by definition, the fugitive emissions from the facility will be zero. However, the WTP emissions will consist of vapor phase organics that are assumed to be derived from valves and other ancillary equipment leaking in WTP process cells. These vapor-phase organic emissions are analogous to fugitive emissions in that the vapor-phase will be unabated by the HEPA filtration systems that control particulate emissions from process cells. Fugitive emissions and unabated organic emissions from process cells are further described in Section 5.4.

The SLRA will not consider emissions associated with accidental releases or with the retrieval and transfer of wastes from the Hanford DST system. Accident scenarios, such as the rupture of a tank or vessel line, are addressed in the hazards analysis and other nuclear and process safety documents. Emissions associated with the transfers from the Hanford DST system are expected to be sufficiently bounded by the WTP process emissions estimates, as described in Section 5.5.

5.2 Process Emissions

The methods, assumptions, and resulting process emission rates are documented in 24590-WTP-RPT-PO-03-008, *Integrated Emissions Baseline Report for the Hanford Tank Waste Treatment and Immobilization Plant*. This report is included as Supplement 2 to this work plan and is summarized below.

The process emissions estimate was developed using the WTP Project's baseline steady-state flowsheet model. The steady-state flowsheet tracks modeled constituents across the PT, LAW, and HLW Facilities, and provides a steady-state representation of process stream compositions at unit operation locations. The steady-state conditions provide an overall material and energy balance with time-averaged flow rates. The steady-state flowsheet allows for the use of simple equipment decontamination factors or more complex thermodynamic calculations to evaluate the modeled constituents of concern. Evaporator partitioning and organic vessel vent emissions were predicted from known liquid-phase concentrations using vapor-liquid equilibrium expressions. Henry's Law constants were compiled for the organic vapor-liquid equilibrium calculations.

Decontamination factors are defined as the ratio of the constituent concentration going into a unit operation to the concentration of the constituent coming out of the unit operation. Decontamination factors for offgas treatment equipment vary from one constituent to another and are established based on the physical properties of a constituent (e.g., offgas phase), published literature, or available research and testing results.

Vapor phase and particle phase emissions are tracked in the emissions model. The offgas phase of a constituent is described by the variable F_v, which denotes the fraction of the ROPC or COPC air concentration in the vapor phase (EPA 2005). Particle phase constituents are defined as having an $F_v < 0.05$ (i.e., having a vapor concentration of less than 5 %). Vapor phase constituents have an $F_v = 1$. A subset of organic COPCs falls into the category of particle-bound ($0.05 \leq F_v < 1$). Particle-bound constituents have a portion of vapor condensed onto the particle surface. The emissions model separately tracks the vapor and particle fractions of particle-bound constituents. Section 6 provides additional discussion of constituent phase and how phase is handled in the air dispersion and risk modeling steps. A complete list of F_v values for COPCs and ROPCs is included in Supplement 4 of this work plan.

The steady-state flowsheet tracks the main constituents expected to have the greatest impact on the material and heat balance of the plant. The emission rates for COPCs not analyzed directly in the steady-state flowsheet (with the exception of PICs) were estimated using the modeling output from a constituent that was in the steady-state flowsheet. The correlations of modeled and unmodeled constituents were based on constituents having similar physical properties, with an adjustment made for differing feed concentrations, if applicable.

The emission rates of PICs were estimated based on research and technology testing data from small-scale melter runs spiked with hazardous organic constituents at the Vitreous State Laboratory of the Catholic University of America.

Additional details on process emissions estimation, including the basis for feed composition, treatment efficiencies, the correlation of modeled and unmodeled constituents, and PIC emission rates are described in 24590-WTP-RPT-PO-03-008.

5.2.1 Total Organic Emission Rate Correction

The WTP emission COPCs and ROPCs include the following categories:

1) COPCs and ROPCs identified as having potential to be present in Hanford tank waste
2) COPCs identified by the EPA as potentially being emitted as PICs during thermal processing of organic materials
3) COPCs detected as PICs during Research and Technology testing of proposed WTP vitrification melters

The organic emissions are determined by stack sampling during demonstration testing of the WTP HLW and LAW melters. Sampling and analytical methods that will be used during the demonstration testing will include those to detect volatile, semi-volatile, and non-volatile feed and PIC species.

Each of these sampling and analytical methods will be calibrated as appropriate to detect organic COPCs. In addition, COPCs that are tentatively identified will be included as part of the known fraction and be quantified in the FRA. The COPCs for which one of the methods is appropriate will be included at the achieved detection limit to provide quantification of the stack concentration of the COPC (C_i). The COPCs will be summed according to their classification as a volatile (C_i^{VOC}), semi-volatile (C_i^{SVOC}), or gravimetric (C_i^{GRAV}) fractions. If a constituent is quantified and not included on the WTP COPC list, it will also be added to the appropriate classification (C_i^{VOC}, C_i^{SVOC}, C_i^{GRAV}) to obtain a sum for each emission fraction. Constituents appropriate to the sampling/analytical methods that were not detected and are not included on the WTP COPC list will not be summed.

The total organic emission (TOE) factors $F_{TOE}{}^{VOC}$, $F_{TOE}{}^{SVOC}$, $F_{TOE}{}^{GRAV}$ will be determined as described below. Each classification of COPC, non-detect (at the appropriate detection limit), tentatively identified compounds (TIC), and the detected constituent will be multiplied by the appropriate TOE factor. These calculated values will be used to assess risks in the FRA.

Only a limited number of organic compounds can be accurately identified and quantified using standard stack gas sampling and analysis methods. A portion of the emissions profile remains unaccounted for. The EPA developed the TOE test to account for unidentified organic compounds because existing methods did not fully determine the total mass of organics present in stack gas emissions. The TOE determination measures organic fractions for three boiling point ranges: (1) a volatile, field gas chromatograph fraction (boiling points less than 100 °C); (2) the semivolatile, total chromatographable organics fraction (boiling points from 100 °C to 300 °C); and (3) the non-volatile, gravimetric (*GRAV*) fraction (boiling points greater than 300 °C). The TOE will be measured during the performance demonstration tests and used in the FRA in conjunction with the identified organic compounds to calculate TOE factors that can then be used to quantitatively evaluate potential risks from the unidentified fractions of organic compounds in the stack gas. A separate TOE factor will be calculated using Equations 5-1 through 5-3 for each fraction.

$$F_{TOE}{}^{VOC} = TO_{TOTAL}{}^{VOC} / \Sigma_i C_i^{VOC} \qquad \text{(Eq. 5-1)}$$

where:

$F_{TOE}{}^{VOC}$ = TOE factor for the volatile fraction (unitless)
$TO_{TOTAL}{}^{VOC}$ = Total volatile organic emission (milligrams per cubic meter [mg/m^3])

C_i^{VOC} = Stack concentration of ith identified volatile COPC (mg/m^3)

$$F_{TOE}^{SVOC} = TO_{TOTAL}^{SVOC} / \Sigma_i C_i^{SVOC} \quad \text{(Eq 5-2)}$$

where:

F_{TOE}^{SVOC} = TOE factor for the semivolatile fraction (unitless)
TO_{TOTAL}^{SVOC} = Total semivolatile organic emission (mg/m^3)
C_i^{SVOC} = Stack concentration of ith identified semivolatile COPC (mg/m^3)

$$F_{TOE}^{GRAV} = TO_{TOTAL}^{GRAV} / \Sigma_i C_i^{GRAV} \quad \text{(Eq 5-3)}$$

where:

F_{TOE}^{GRAV} = TOE factor for the nonvolatile fraction (unitless)
TO_{TOTAL}^{GRAV} = Total nonvolatile organic emission (mg/m^3)
C_i^{GRAV} = Stack concentration of ith identified nonvolatile COPC (mg/m^3)

Using the assumption that the unknown portion of the emission is similar in toxicity and chemical properties to the known compounds, a risk will then be attributed to the unknown portion of the stack emission by multiplying the emissions rate of each identified compound by its fraction's TOE factor. The application of the TOE factors will be discussed in the FRA as an uncertainty that has potential to overestimate and underestimate risks, depending on whether fate and transport and/or toxicological data are available for the identified compounds. The TICs described in this section will be included in identified compound fractions for the purposes of determining the TOE factors.

5.2.2 Estimating Emissions of Nondetect COPCs

Nondetect COPCs and ROPCs will be managed as follows:

- If the compound is in the surrogate feed used during demonstration testing, it is assumed present at the detection limit
- If the compound is on the COPC list and not detected, it is assumed present at one-half the detection limit
- If the chemical is not on the COPC list, not a risk driver, and not detected in any of the test runs, assume the chemical is not present
- If the chemical is a risk driver (PAHs, PCBs) and not found, assume it is present at the detection limit
- If the chemical is detected in one run but not in others, assume the detected value and one-half the detection limit for the other runs

Whether a compound is detected will be based on the detection limits as described below for the non-isotope and isotope dilution methods.

The FRA will use the methodology recommended in HHRAP to quantify nondetects for COPCs analyzed with non-isotope dilution methods. A nondetect in this case would be a value below the reliable detection limit (RDL). The RDL is defined as 2.623 times the method detection limit (MDL). The MDL is defined

as the minimum concentration of a substance that can be measured (via non-isotope dilution methods) and reported with 99 % confidence that the analyte concentration is greater than 0. The MDL is determined from analysis of a sample in a specific matrix type containing the analyte, and is considered the lowest level at which a compound can be reliably detected. Procedures for determining an MDL are specified in 40 CFR 136, Appendix B.

The FRA will also follow the HHRAP recommendation that the "method-defined estimated detection limit (EDL)," as defined by SW-846 (EPA 1986), be used to quantify nondetects for COPCs analyzed with isotope dilution methods. The EDL is defined as a laboratory estimate of the concentration of a given analyte required to produce a gas chromatogram signal with a peak height of at least 2.5 times the background signal level.

5.2.3 Blank Corrections

Blank samples are used as a quality control check and are intended to indicate whether contamination was introduced into a sample in the field while the samples were being either collected, transported to the laboratory, or prepared and analyzed. This helps ensure that the measured levels of target analytes are indeed from the vitrification system and not from prior contamination of the sampling train. Corrections to account for concentrations of compounds detected in blank samples will be applied only to metals, following procedures outlined in EPA Method 29, *Determination of Metals Emissions from Stationary Sources* (40 CFR 60). No blank correction factors will be applied to the results from any other analytes. The rationale for this distinction is discussed below.

The overall basis for not allowing blank correction of emissions data used in this risk assessment is the assumption that blank correction will reduce the accuracy of the determination and would represent a non-conservative uncertainty. Consequently, disallowing these blank corrections is a conservative assumption that is consistent with a screening-level risk assessment. This limits the use of blank data to providing the basis, if necessary, for retesting. The EPA stack sampling methods are not explicitly designed for generating data to be used in risk assessment. The fact that these methods may provide guidelines for blank correction of data does not automatically provide a facility assurance that blank correction will be allowed or if allowed that the extent of correction delineated in the method will be allowed. Also, caution must be practiced in applying blank results to correct or qualify sample results for any purpose, as blanks are provided in minimal quantities (e.g., one per test condition, or one per test) and therefore, are at best only qualitative indicators of the validity of a data set.

The approach for blank correction described in 40 CFR 60, Method 29, is very detailed. (It is one of the few EPA methods that provides for subtraction of reagent blank values within the limitations of the method specifications). This is identical to the approach described in EPA SW-846, Method 0060, which was originally designed to meet the data needs for hazardous waste incinerators and boiler and industrial furnaces risk evaluations. As with all the emission testing, every reasonable effort to identify potential for contamination and to minimize that potential will be made. These efforts will be taken into consideration, as well as the extent of any contamination, when determining the data to input into the risk assessment.

5.2.4 Tentatively Identified Compounds

The HHRAP guidance recommends identifying and quantifying as many non-target organic compounds as possible from the emission test results, regardless of the compounds' toxicity. Identifying a large portion of the "unknown" peaks in a gas chromatogram leads to a more complete organics mass balance, and less uncertainty in the overall risk evaluation. The 30 largest TICs, for which the peaks are greater

than 10 % of the nearest internal standard, will be identified, quantified, and added to the list of detected compounds from the vitrification system. These compounds will then be evaluated in the same manner as any other detected compound. The inclusion of TICs quantitatively in the risk assessment will be discussed in the uncertainty section as having potential to overestimate and underestimate risks.

5.2.5 Maximum Emissions Rate Correction

To the greatest extent possible, emissions rates during the vitrification systems' performance demonstration testing will be measured under what would be considered "worst-case" operating conditions. Reasonable maximum emissions rates will be determined in accordance with current HHRAP guidance by using the maximum of the three emission rates identified for each COPC or ROPC during a particular test condition, adjusted for process upsets.

5.3 Process Upset Emissions

Process upset conditions include periods of startup, shutdown, process malfunction (i.e., the unit is operating outside the permitted operating conditions), or equipment failure. Periods when process equipment is being maintained or in an idle condition are also included. Process upset conditions are generally assumed to result in greater than normal stack emissions during the short period of the upset. However, EPA has indicated that upsets are not generally expected to significantly increase stack emissions over the lifetime of a facility (HHRAP).

The potential for increased emissions during upset events will be addressed through the application of upset factors. These upset factors, as described below, will be applied (i.e., adjustments will be made) to the estimated emissions that are environmentally modeled. These upset factors are based on the amount of time the facility is expected to operate in an upset condition and the estimated magnitude of stack emissions during upset relative to routine operating conditions. The preferred method for estimating this upset factor is through the use of data from existing facilities that have operating conditions similar to the proposed WTP. The frequency and duration of upset events may be estimated based on the HHRAP:

- Data from continuous emissions monitoring systems that measure operating parameters such as stack carbon monoxide or oxygen
- Data on combustion chamber, air pollution control system (APCS), or stack gas temperature
- Ratio of automatic waste feed cut-off frequency and duration to operating time
- Variations in the APCS operating conditions

The potential magnitude of emissions during upset events may be estimated based on stack test data collected during upset conditions.

The EPA default upset factors represent worst-case conditions and will be used for the PRA. The EPA default upset factors are based on the data described above from operating hazardous waste combustion facilities. The default upset factors are expected to over-predict upset emissions from the WTP for several reasons, including:

- Carbon monoxide is frequently used as an indicator of upset conditions, and automatic waste feed cut-offs are often triggered by increased stack gas concentrations of carbon monoxide. However, routine operations, such as adjusting waste feed or air intake rates, will cause brief spikes in carbon monoxide concentration.

- Test data used for these defaults is based on hazardous waste combustion facilities designed for the destruction of liquid or solid organic waste, or both. The technology and waste feed of the WTP melters are different and less subject to upset than these facilities.

The HHRAP default upset factors are 2.8 for organic chemicals and 1.45 for metals, calculated as shown below.

Organics. A default facility is assumed to operate under upset conditions 20 % of the time and stack emissions are assumed to be 10 times greater than normal during this time:

Upset Factor = (0.80) (1) + (0.20) (10) = 2.8

Metals. A default facility is assumed to operate under upset conditions 5 % of the time with stack emissions 10 times greater than normal during this time:

Upset Factor = (0.95) (1) + (0.05) (10) = 1.45

The EPA has not determined a default upset factor for radionuclides. For the PRA, radionuclides are assumed to behave similarly to metals, with an upset factor of 1.45. The same upset factors will be used for both the plausible and worst-case scenarios in the PRA and the FRA.

These default upset factors (2.8 for organics and 1.45 for inorganics and radionuclides) will be used for all vapor-phase emissions. An upset factor of one (1) will be used for all particle and particle-bound emissions, as described below.

The entire pretreatment and vitrification processes will be contained within buildings designed such that the only exits for air and emissions will be through one or more HEPA filters. When the process is operating normally, all air and emissions will pass through numerous air pollution control devices. However, even if the process experiences an upset condition or shuts down and all of the active pollution control devices operate poorly or fail completely, the only way for air and emissions to pass out of the facility will be through the HEPA filters.

The removal efficiency for a single stage of HEPA filtration is, by definition, 99.97 % (decontamination factor = 3333) for 0.3-μm particles. This decontamination factor applies to the efficiency of the HEPA filter material. According to the *Nuclear Air Cleaning Handbook* (DOE 2003), the theoretical removal efficiency for multi-stage HEPA filtration systems is 3333^n, where n is the number of HEPA filter stages.

For the WTP, all multi-stage HEPA filter designs consist of two stages of filters in series. The theoretical maximum decontamination factor for two-stage designs would be 11,108,889. The Handbook (DOE 2003) states that for systems that adhere to the design, construction, testability, and maintainability of ASME N509, an appropriate multi-stage decontamination factor under normal operating conditions is 3000^n. The theoretical maximum decontamination factor under this method would equate to a decontamination factor of 9,000,000.

For conservatism, WTP has assumed that the decontamination factor of the first stage filter is 2000 and the decontamination factor of the second stage filter is 100. The two-stage HEPA filter decontamination factor for the WTP is, therefore, 2000 (1st stage) times 100 (2nd stage) = 200,000.

Therefore, an upset factor of one (1) will be applied to the particulate and particulate-bound emissions estimates for organics, inorganics, and radionuclides because the HEPA filter removal efficiency used in the emissions estimate already includes an assumption of decreased removal efficiency due to upset conditions such as moisture in the filters.

5.4 Fugitive Emissions

Fugitive emissions are defined as "emissions, which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening" (WAC 173-400-030, *General Regulations for Air Pollution Sources*). The WTP process buildings that manage the Hanford tank waste will be operated under negative pressure, and the air from the process buildings will be released to the atmosphere through a stack or flue. Transfer lines between buildings that will contain Hanford tank waste will be double-wall pipe. Therefore, the WTP will not emit fugitive emissions.

Building ventilation and process offgases will be treated by abatement systems that employ best-available control technology for criteria pollutants, radionuclides, and toxic air pollutants prior to release to the environment through a stack or flue. Organic compounds could be released into the process cells from ancillary equipment. These emissions will be treated by HEPA filters that will abate particulate or particle-bound organic compounds. Organic compounds existing in the vapor phase will not be captured by the HEPA filters. These organic emissions from process cells have been quantified for purposes of risk assessment.

Organic emissions from process cells will be quantified by establishing the total organic emissions associated with ancillary equipment in process cells. This total includes particle, particle-bound, and vapor-phase contributions that are associated with ancillary equipment, such as valves, pump seals, compressor seals, and connectors. The methodology and emissions factors used to estimate releases from ancillary equipment are consistent with the EPA guidance document *Protocol for Equipment Leak Emission Estimates* (EPA 1995). After establishing the total organic emissions, the fraction of emissions considered to be particle or particle-bound in the offgas will be removed. The particle and particle-bound organic constituents will be captured by HEPA filtration systems in the process cell ventilation system where the concentration is reduced by a factor of 200,000 (Supplement 2, 24590-WTP-RPT-PO-03-008). The remaining vapor-phase organic fraction will be carried forward to the corresponding facility flue where the emission rates are considered in conjunction with other process emissions for risk assessment.

A detailed discussion of the methods, calculations, and results associated with organic emissions from process cells is described in 24590-WTP-HAC-50-00001, *Estimated Organic Emissions from Process Cells*. This calculation is included as Supplement 3 to this work plan.

5.5 Uncertainty in WTP Emissions Estimate

Although there are uncertainties associated with the parameters used to arrive at estimated process emissions, these uncertainties have been recognized and managed through conservative assumptions applied throughout the emissions estimation process. For example, analytical uncertainty is associated with the organic, inorganic, and radionuclide characterization data that describes the waste feed streams to the WTP. To accommodate characterization uncertainties, the inorganic and radionuclide source terms are based upon the known concentrations for constituents in tanks that the WTP expects to process.

Because less data are available for organics in the tank waste, conservatism has been applied with respect to the organic feed vector. For organic compounds, the emission estimate assumes that incoming organic

concentrations are elevated by applying a scalar such that uncertainty in the feed vector is compensated for and sufficiently bounded (24590-WTP-RPT-PO-03-008). The methodologies applied to assigning feed concentrations should ensure that the actual concentrations of organic, inorganic, and radionuclide constituents encountered during operations will be conservatively bounded by the emissions estimate assumptions.

The conservatism applied to the feed vector is also applied to the assignment of equipment decontamination factors. In cases where a particular treatment process has a range of achievable treatment efficiencies, the lower end of the range (which translates to the higher offgas emission rate) has been applied in the emissions estimate. The ranges of treatment efficiencies for individual treatment processes are derived from a variety of sources, including research and technology data, engineering studies, vendor literature, and regulatory guidance. For example, in establishing filtration removal efficiencies, the dual-HEPA filtration systems used in the WTP offgas treatment systems have an assumed decontamination factor of 200,000 for particle and particle-bound constituents in the offgas (24590-WTP-RPT-PO-03-008). This decontamination factor is consistent with the assumptions used across other Hanford permitting applications and is considered conservative, even for particle sizes of 0.3 μm, which are most likely to pass through HEPA filtration.

The WTP emissions estimate does not estimate the emissions that could result from retrieval of waste feed from the Hanford DSTs. Although these emissions are not included, the risks associated with retrieval of DST feeds will be sufficiently bounded for the following reasons:

- The WTP feed vector assumes receipt of the entire DST inventory, and has been developed to conservatively overestimate the constituent concentrations present in the tank contents. As described above, the organic feed vector scaled up expected feed concentrations to account for uncertainties in characterization information.
- DST retrieval operations would be infrequent and, therefore, the assumed continuous 24 hours per day, 7 days per week, operation of WTP at 100 % efficiency would dominate any long-term risk calculations. Any acute risks associated with the DST retrieval are not expected to coincide with either the timing or location of acute risks estimated for the WTP due to temporal and spatial differences.
- Entrainment losses of particle-bound constituents from the DST tank system would be comparable to the control in the WTP facility (i.e., both offgas discharge streams are controlled by HEPA filtration systems that provide a high removal efficiency for particulates).
- Losses of all constituents are being assessed and controlled under regional air-permitting control authorities.

Based on the above description, the uncertainties associated with not including the DST emissions are likely bounded by the WTP estimates. The DST transfers to the WTP will likely neither over- or under-estimate the risks.

5.6 References

5.6.1 Project Documents

24590-WTP-HAC-50-00001, *Estimated Organic Emissions from Process Cells.*

24590-WTP-RPT-PO-03-008, Rev 0, *Integrated Emissions Baseline Report for the Hanford Tank Waste Treatment and Immobilization Plant.*

5.6.2 Codes and Standards

40 CFR 60. App. A-8. "Method 29 - Determination of Metals Emissions from Stationary Sources," US Environmental Protection Agency, *Code of Federal Regulations*, as amended.

40 CFR 136. App. B. "Definition and Procedure for the Determination of the Method Detection Limit -Revision 1.11," US Environmental Protection Agency, *Code of Federal Regulations*, as amended.

WAC 173-400-030. *General Regulations for Air Pollution Sources*, Washington Administrative Code, last updated 7 July 2002.

5.6.3 Other Documents

DOE. 2003. *Nuclear Air Cleaning Handbook*, DOE-HDBK-1169-2003, November 2003, US Department of Energy, Washington, DC.

EPA. 1986. *Test Methods for Evaluating Solid Waste, Physical and Chemical Methods*, SW-846, Third Edition (as amended by Updates I, II, IIA, IIB, and III). US Environmental Protection Agency, Washington, DC.

EPA. 1995. *Protocol for Equipment Leak Emission Estimates*, EPA-453/R-95-017. US Environmental Protection Agency, Research Triangle Park, North Carolina.

EPA. 2005. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, Final, EPA/530/R-05/006. US Environmental Protection Agency, Washington, DC.

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6 Environmental Modeling

Environmental modeling refers to several types of models used to simulate the route of chemicals and radionuclides from the stack toward human and ecological receptors. This section describes the environmental modeling approach for the WTP. Air dispersion modeling is discussed first (Section 6.1), followed by soil accumulation modeling (Section 6.2), surface water accumulation modeling (Section 6.3), sediment accumulation modeling (Section 6.4), and terrestrial plant accumulation modeling (Section 6.6). Modeling for other media (such as specific animals and fish) is briefly discussed in Section 6.7 (more detailed information is provided in Sections 7 and 8, because these media are modeled slightly differently for human health and ecological risk). Uncertainties related to environmental modeling are discussed in Section 6.8. A summary of environmental modeling is presented in Section 6.9.

6.1 Air Dispersion Modeling

Air dispersion modeling will be used to estimate the ambient air quality and deposition rates resulting from emissions of vapor, particle-bound, and particle-phase chemicals and radionuclides during operations of the WTP. This section provides details of the approach that will be used in this task. Specific air model settings are described in the *Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol* (24590-WTP-RPT-ENV-08-001, Supplement 5).

6.1.1 Model Selection

The Industrial Source Complex Short Term Model, Version 3 (ISCST3) (EPA 1995, EPA 2002) was initially proposed to evaluate the air quality in the vicinity of the WTP. This model, preferred by the EPA (*Guideline on Air Quality Models*, 40 CFR 51, Appendix W)[1], is generally considered a conservative model for applications such as the SLRA. The model uses emissions source data and hourly meteorological data to estimate ambient air concentrations and deposition rates of gases and particles at locations (receptors) of interest in the vicinity of the facility (EPA 2002). The ISCST3 is an Eulerian "plume" model that sends emissions out in a straight line from the emission source, in the direction of the wind at the time of release. The plume continues spreading out and traveling away from the emission source, becoming more and more dilute with distance. The use of this model was evaluated for application to the WTP.

After this initial evaluation, it was determined that the CALPUFF model, a Lagrangian "puff" model, would be more appropriate in this application. The EPA adopted CALPUFF as a guideline model and added it to 40 CFR Part 51, Appendix W (*Federal Register*, 15 April 2003), giving it equivalent status to the AERMOD model for long range transport. The air modeling regulation, 40 CFR 51, Appendix W, provides for case-by-case approvals for other uses of CALPUFF, provided that it is demonstrated to be suitable. In addition, there are several advantages to using the CALPUFF modeling system (Version 5.6) for this application, which would result in a more realistic and representative characterization of the air quality:

- **Gaussian puff dispersion formulation**: Plumes are treated as a series of Gaussian puffs that move and disperse according to local conditions that vary in time and space.

[1] Note, ISCST3 has subsequently been replaced by AERMOD as the preferred model in 40 CFR 51, Appendix W.

- **Meteorology:** Wind and other meteorological variables are allowed to vary in a three-dimensional space.
- **Wet- and dry-deposition mechanisms**: Deposition processes are included for particle and vapor phase pollutants that depend on the characteristics of the pollutant, the surface geophysical parameters, and meteorological conditions; the model accounts for the mass of pollutant removed from the plume when deposition occurs.
- **Other improvements and refinements:** The algorithms in CALPUFF have been designed to take advantage of recent improvements in scientific understanding of boundary layer meteorology, dispersion modeling, and chemistry.

The most significant advantage the CALPUFF modeling system provides, in comparison to other dispersion models (such as ISCST3) that use meteorological data from a single station, is a more realistic treatment of the wind field, including upper air data. The CALPUFF model gets the upper air data input from the Mesoscale Model, version 5 (commonly known as MM5). The MM5 model was run for Washington, Oregon, part of Idaho, and British Columbia by the University of Washington. MM5 is a prognostic model that produces gridded upper-air wind fields and is used as input into the CALPUFF model. "Gridded wind fields" indicates that the model provides wind speeds and direction at specific intervals (4 km) over the modeling region. The CALPUFF upper air input is much more comprehensive than simply using a single set of upper air data from one station. Also, note that rather than performing external calculations of the mixing height and providing these results as input into the model (when using ISCST3), CALPUFF handles those calculations internally, since it has a very comprehensive set of meteorological data as input. Surface wind regimes typically have complex, three-dimensional qualities that are significantly influenced by geophysical parameters, such as topography, so that a single-surface observation site is often not sufficient to accurately characterize the wind flow regime in a region. CALPUFF's three-dimensional wind field provides a more accurate representation of the wind flow influencing regional air quality impacts. The CALPUFF model releases the pollutant puffs into that three-dimensional wind field, which has varying wind flow patterns and accounts for complex terrain features, thereby producing a more realistic depiction of dispersion.

One of the unique characteristics of Hanford is that Battelle's Pacific Northwest National Laboratory (PNNL) operates the meteorological monitoring network in and around the Hanford site. There are 30 surface monitoring stations included in the network, which provides a comprehensive set of meteorological conditions throughout the Hanford site and in surrounding areas (8 stations are located outside the Hanford site boundary). Data from 26 of these stations will be included in the CALPUFF run to provide a very representative picture of surface meteorological conditions in the region around the WTP site.

All of the monitoring stations measure wind speed and direction at 10 m above ground level and temperature at 1 m above ground level. Other variables to be used in the modeling, including relative humidity, dew-point temperature, barometric pressure, cloud cover, and ceiling height are only measured at the main Hanford Meteorological Station, which is located near the center of the Hanford site and approximately 5 miles west of the 200 East Area location where the WTP will be located. These supplemental data are expected to be representative of atmospheric conditions at the WTP.

The CALPUFF system consists of three main components: CALMET, CALPUFF, and CALPOST. The approved versions of the CALMET, CALPUFF, and CALPOST programs was used in this analysis and is supplemented by EPA's *Risk Assessment Guidance for Superfund* (RAGS), Part A (EPA 1989), and RAGS Part B (EPA 1991) models for radionuclides. This model can handle a large number of sources

that could occur from a typical industrial source, including point sources (such as stacks) and area sources (such as fugitive emissions from an open area). In the case of the WTP, there are no fugitive emissions, and CALPUFF is used exclusively for point source emissions.

The CALPUFF model is used to calculate ambient concentrations and wet and dry deposition rates for COPCs and ROPCs at pre-determined exposure locations. The terrain elevation of each receptor is included in the model input. Terrain elevations are obtained from digitized maps of the Hanford Site for receptors located within the site or from US Geological Survey (USGS) digitized maps for receptors located outside of the site.

6.1.2 Detailed Discussion of CALPUFF Modeling

The following sections present an overview of the components in the CALPUFF modeling system, the application of the CALPUFF model, and post-processing of CALPUFF results to determine air quality impacts.

Sufficient data is available from a variety of sources to run the CALMET, CALPUFF, and CALPOST components. The CALMET module is used to combine various types of meteorological and geophysical data with the necessary control information into the particular format required for use in the dispersion-modeling component of the CALPUFF model. CALPOST is then used as a post-processing program to read the formatted output file generated by CALPUFF and summarize modeled results. The objective of this section is to describe the collection, preparation, and application of all data necessary to run the CALPUFF modeling system. *Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol* (Supplement 5) discusses the model settings in detail; the discussion below provides background information and highlight model settings that were modified from default values, and subsequently validated through an independent assessment and comparison of model results to actual observed weather data (24590-CM-HC4-HKYM-00001-01-00002).

6.1.2.1 CALMET Modeling

The CALMET model uses a grid system consisting of square horizontal cells (*NX* by *NY*) and vertical layers (*NZ*) to create a three-dimensional wind field over a specified domain area. To develop the wind field in the domain area, the model must start with an initial "guess" field. Several options are available for initializing the wind field, including a spatially uniform guess field or objective analysis of all available weather observations; however, use of output data from a gridded prognostic model (such as Pennsylvania State's Mesoscale Model 5 [MM5]) is preferred due to its ability to provide a spatially varying wind field and take into account geographic features influencing mesoscale wind patterns. Once defined, this initial wind field is adjusted objectively using local geophysical data and surface meteorological observations.

In addition to MM5 data, the CALMET model incorporates a variety of other meteorological and geophysical datasets in developing the three-dimensional wind fields, including upper air, surface, precipitation, terrain, and land use data. Surface and upper air observations are used to refine the MM5 predictions to account for local scale effects not resolved by the MM5 prognostic model. Inclusion of geophysical data further influences the development of the wind fields, especially in complex flow applications and light wind situations where terrain-induced flows dominate surface wind patterns. The CALMET model is used to combine MM5 simulation data with surface meteorological observations, upper air observations, and geophysical data into the format required by the dispersion-modeling component CALPUFF.

The following sections briefly discuss the preparation of the meteorological and geophysical datasets, as well as the application of the CALMET module.

6.1.2.2 Preparation of Data

MM5 Data. A five-year subset of the University of Washington's archived MM5 data, spanning 1 January 2002 to 31 December 2006, was obtained and used in this modeling application. The data were processed using the CALMM5 module, which processes the MM5 data for direct input into the CALMET model.

Surface Data. Surface meteorological measurements are used in the construction of CALMET input files to supplement the MM5 wind data in defining the three-dimensional wind field. Hourly surface meteorological data was obtained for the 1 January 2002 to 31 December 2006 period from 26 of the 30 stations comprising the Hanford Meteorological Monitoring Network. These stations cover all quadrants of the Hanford Site and provide a comprehensive set of representative surface wind data for the area. All of this data is used in developing the three-dimensional wind field for each hour of the five-year modeling period. In addition, the main Hanford Meteorological Station, located near the center of the Hanford site, collects precipitation and cloud cover data that is used in the model. The stations are operated by Mission Support Alliance (MSA) on a continuous basis; MSA maintains a comprehensive quality assurance program to ensure the quality of the data collected in the Hanford Meteorological Monitoring Network.

Integration of MM5 and Surface Data. The three-dimensional wind field model uses a combination of upper-level MM5 data and surface data to adequately describe wind conditions at plume height. Most surface data is collected from towers at heights of 10 m; the highest surface collection height is 124 m.

Geophysical Data. Land use and terrain data are both incorporated into the CALMET module to modify wind field projections and, subsequently, affect dispersion calculations in the CALPUFF model. Terrain height and land use data are obtained electronically from the USGS's website (http://edcftp.cr.usgs.gov/pub/data/landcover/states/washington.nlcd.bin.gz, accessed 2010) and pre-processed using the software provided in the CALPUFF modeling system. Terrain data is available for digital elevation model data with each file covering a 1° (latitude) by 1° (longitude) area corresponding to the east or west half of a 1:250,000 (1°-latitude by 2°-longitude) topographic map. The terrain dataset's resolution varies from 70 m to 90 m in North America, with an absolute accuracy of 130 m in the horizontal and 30 m in the vertical.

Land use data is also available from the USGS's website at the 1:250,000-scale. Each land use file covers the full 1° (latitude) by 2° (longitude) area corresponding to a 1:250,000-scale topographic map with approximately 200 m resolution.

6.1.2.3 CALMET Input Assumptions

The CALMET program requires inputs regarding wind characteristics and the potential influence of land terrain on wind patterns. Assumptions regarding the validity or relative importance (i.e., weight) of surface wind observations and upper air data must be programmed into CALMET to enable the model to predict conditions within a three-dimensional wind field over a specified domain area. These parameters deal with the CALMET model's treatment of surface and upper air wind data in developing the wind field (Table 6-1). Supplement 5 provides additional detail about specific model settings.

BIAS. BIAS is the relative weight that is given to the vertically extrapolated surface wind observations versus the upper air data. The "initial guess wind field" developed by the CALMET model is computed as an inverse distance weighting of the surface and upper air observations, modified by the height-dependent bias factors (BIAS). BIAS is a layer-dependent factor that modifies the weights of surface and upper air data. Negative BIAS reduces the weight of upper air observations (e.g., BIAS = -0.1 reduces weight of upper air data by 10 %; BIAS = -1.0 reduces weight by 100 %). Positive BIAS reduces the weight of surface stations (e.g., BIAS = 0.2 reduces the weight of surface stations by 20 %; BIAS = 1 reduces their weight by 100 %). Zero BIAS leaves weights unchanged from the inverse distance weighting function. A value of BIAS must be entered for each vertical level being modeled.

For example, upper air observations may be given little weight within a local valley, where surface observations may better reflect wind flow patterns. Similarly, upper air observations may be given heavy weight above the valley, while the surface observations can be eliminated above the valley. BIAS may be important, because the model may have difficulty in overcoming a poorly defined initial guess wind field. BIAS is used to enable CALMET to compute more accurate and smooth transitions between wind vectors such that unrealistic wind conditions are not produced. CALMET BIAS will be set at 0 (default) to represent 9 vertical levels, ranging from the surface to 4000 m.

IEXTRP. The vertical extrapolation of surface wind observations is provided through the variable IEXTRP. This option is used to calculate the winds at levels above the surface (typically wind speeds increase with height above the surface, and this must be taken into account). IEXTRP has four options:

- IEXTRP = 1 do not extrapolate the surface data
- IEXTRP = 2 extrapolate vertically using a power law equation
- IEXTRP = 3 extrapolate vertically using user-defined scaling factors
- IEXTRP = 4 extrapolate vertically using similarity theory

IEXTRP will be set equal to 4.

R1. R1 is a weighting parameter for the diagnostic wind field in the surface layer. This parameter controls the relative weighting of the first-guess wind field produced by the diagnostic wind field model and the surface layer observations. R1 is the distance from an observation station at which the observation and the first-guess wind field are equally weighted.

There is no default value provided for this parameter in the model guidance. R1 will be set equal to 10.

R2. R2 is a weighting parameter for the diagnostic wind field in the layers aloft. This parameter controls the relative weighting of the first-guess wind field produced by the diagnostic wind field model and the upper air observations. R2 is the distance from an observation station at which the observation and the first-guess wind field are equally weighted.

There is no default value provided for this parameter in the model guidance. R2 will be set equal to 12.

RMAX1. An observation is excluded from interpolation if the distance from the observation station to a particular grid point exceeds a maximum radius of influence. RMAX1 is the radius of influence over land in the surface layer (km).

This parameter should reflect the limiting influence of terrain features on the interpolation at the surface. Larger terrain features will tend to reduce RMAX1, although no default value is given in the model guidance. RMAX1 will be set equal to 12.

RMAX2. An observation is excluded from interpolation if the distance from the observation station to a particular grid point exceeds a maximum radius of influence. RMAX2 is the radius of influence over land in the layers aloft (km).

RMAX2 is generally larger than RMAX1 because the effects of terrain decrease with height. RMAX2 will be set equal to 12.

6.1.2.4 CALMET Application

The first phase of this modeling analysis will involve the production of the three-dimensional meteorological fields to be used by the CALPUFF modeling system to characterize pollutant dispersion. The CALMET model is used to generate these wind fields, which are then input into the second module of the system, the dispersion model CALPUFF. A CALMET input file is developed to define all control information and coordinate all datasets necessary for a model run. CALMET is applied using the previously described datasets and the methods explained below.

The CALMET model will be run for a 100 km by 100 km grid with a 1 km grid mesh size and 9 vertical levels, ranging from the surface to 4000 m. The CALMET grid is centered in the middle of the Hanford site, near where the WTP facilities are to be built, so that the CALMET model grid extends approximately 50 km in all directions from the WTP facility (see Figure 6-1).

6.1.2.5 CALPUFF Modeling

This section describes the preparation of the input data necessary for the second module of the CALPUFF system, the dispersion model CALPUFF. This data includes source characteristics, modeling options, and receptor locations. Air quality impacts of emissions from the proposed WTP at the Hanford site are estimated from CALPUFF model simulations using the year of CALMET-generated meteorological fields previously discussed.

Building wake effects can have a significant impact on the dispersion of emissions near a stack. The turbulence induced by buildings produces a phenomenon, known as *building downwash*, in which a stack plume can be brought downward toward the ground much sooner than if the buildings were not there, resulting in localized areas of elevated emission concentrations. The CALPUFF model has built-in algorithms to evaluate the potential for downwash.

6.1.2.6 CALPUFF Model Options

The EPA has provided guidance for the operation of both the CALMET and CALPUFF models (Earth Tech Inc. 2000a, 2000b). This guidance is used to determine the most appropriate model options and settings used for these models. Some of the key options proposed for this application of the CALPUFF model are as follows:

- Wind speed profile: Industrial Source Complex model – rural
- Plume element modeled: puff

- Pasquill-Gifford dispersion curves used with other default dispersion options
- CALPUFF partial path treatment of terrain
- Transitional plume rise, stack downwash, and partial plume penetration modeled
- Default wet and dry deposition parameters for the particle and vapor deposition

The model will be run for six scenarios to determine the location of the maximum impacts, ensure that the grid is sufficiently extended to capture the worst-case depositions, and focus on areas of particular interest to the risk assessment:

- Point of maximum onsite impact (100 m receptor grid spacing), Figure 6-2
- Downwind offsite impact area (500 m receptor grid spacing), Figure 6-3
- In the vicinity of Gable Mountain (500 m receptor grid spacing), Figure 6-4
- Along the Columbia River (500 m receptor grid spacing), Figure 6-5
- Hunter/Gatherer area along the site perimeter (current exposures, 1 km receptor grid spacing), Figure 6-6
- Hunter/Gatherer area within the site interior (future exposures, 1 km receptor grid spacing), Figure 6-7

6.1.3 Other Modeling Parameters

This section discusses the modeling input parameters for the air dispersion and deposition modeling including emissions data, meteorological data, exposure locations, calculations of deposition rates, and model variable settings.

6.1.3.1 Emissions Source Information

Identification of emission sources and quantification of emission rates for each specific COPC and ROPC are described in Section 5, Estimation of Emissions. Stack heights for the WTP have been established at about 200 feet (about 61 m). Data required for model execution, such as stack diameters, stack gas flow velocities, and stack gas temperatures, is provided in Supplement 5. The data will be updated in the PRA.

Unit Emission Rates. The CALPUFF model is run with unitized (normalized) 1.0 g/s emission rates for both particles and vapors from each facility stack. The vapor and particle fractions of particle-bound constituents are modeled separately in CALPUFF. There is a linear relationship between the emissions rate from a single stack and the modeled impacts (air concentrations and deposition rates) at an individual location. Therefore, the modeled impact at that location, based on a unit emissions rate from a single stack, can simply be multiplied by the actual emissions rate of an individual COPC and ROPC to determine the actual depositions. By using spreadsheets, the impacts from a specific stack can be determined for each COPC and ROPC at each location in the receptor grid.

Analysis of Multiple Flues. The current WTP design is based on nine flues contributing primarily to COPC and ROPC emissions, with an additional five exhaust flues that contribute primarily to stack flow rate. These flues are bundled together in their respective stacks in the PT, HLW, and LAW Facilities. In actuality, the facility stacks are structural steel lattices that support the individual flues for that facility. The PT stack contains the process vessel vent flue, the pulse jet vessel exhaust flue, and the C2, C3, and C5 exhaust flues (facility ventilation). The HLW stack contains the HLW pulse jet vessel exhaust flue,

two HLW melter flues, the IHLW storage area exhaust flue, and the C3 and C5 exhaust flues (facility ventilation). The LAW stack contains the LAW melter offgas flue, and the C3 and C5 exhaust flues (facility ventilation). The contribution of each flue (gas temperature, humidity, and flow rate) will be combined such that an "effective" stack for each facility can be modeled separately in the air dispersion modeling process (see *WTP Stack Parameters and Flow* [24590-WTP-HPC-M30T-00002]).

All air dispersion modeling information (including but not limited to input files, meteorological data, and output files) will be provided in electronic format with the risk assessment reports.

6.1.3.2 Calculation of Deposition Rates

The determination of deposition rates is an important input into the human health and ecological risk assessments being conducted for the WTP. The CALPUFF model will be used to calculate both wet and dry deposition rates, in addition to ambient concentrations, at each exposure location.

Dry deposition occurs in the absence of precipitation; wet deposition is influenced by precipitation type and rate. The two types of deposition result from different physical processes and, therefore, must be considered separately. CALPUFF has algorithms built into the model to calculate these processes. CALPUFF requires the use of many parameters. The CALPUFF model was run using the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 recommendations, with minor exceptions. The WTP Project met with Ecology and EPA on August 15, 2007, to review model settings and assumptions. In a subsequent meeting, the WTP Project and Ecology concurred with the proposal to remove the Rattlesnake Mountain meteorological station (Station 20) from the CALMET inputs (CCN 194345). Modeling was conducted using the settings agreed to during these meetings. This CALPUFF run will be updated with the latest flue and stack design parameters before running the risk assessment model runs (PRA and FRA).

Dry Deposition. The CALPUFF model calculates the deposition velocity from particle diameter, mass fraction, and particle density, which are the data input into the model for each particle size-fraction. The calculation of deposition velocities within the model includes the effects of Brownian motion, inertial impaction, and gravitational settling. Particularly for the larger particles, the key parameter governing the rate of dry deposition is the terminal settling velocity. The terminal settling velocity, in turn, is affected primarily by the particle size and density; large particles have the highest terminal velocities (and, therefore, the highest deposition rates), and small particles have lower terminal velocities. It is important to note that particles have a positive terminal settling velocity and, therefore, are subject to dry deposition.

Wet Deposition. The wet-deposition flux is calculated by using a scavenging ratio to model the wet removal of particles and gases in the atmosphere. The scavenging coefficient appears to depend on a complex combination of the characteristics of the COPC and ROPC (such as solubility and reactivity for gases; size distribution for particles), as well as the nature of the precipitation (such as liquid or frozen). The input screens of the CALPUFF model have suggested scavenging coefficients for use in the model.

Scavenging Coefficient for Wet Deposition. An empirical scavenging coefficient approach is used in CALPUFF to compute the plume depletion and wet deposition fluxes due to precipitation scavenging. Generally, soluble species have higher values for scavenging coefficients than insoluble species.

This parameter may be of only limited importance at Hanford because of the small number of wet scavenging events that occur in the area on an annual basis. Scavenging coefficients for wet deposition are presented in Table 6-1.

Deposition Rate Calculations. The COPC and ROPC emissions can occur in either the vapor or particle phase, and COPCs and ROPCs in both phases are subject to wet and dry deposition. Particle size is a primary influence on the calculation of both dry and wet deposition of COPCs and ROPCs in the particle phase. Therefore, distribution of particle sizes in the stack emissions at the WTP is an important input parameter in the model for determining deposition rates. Particles released from the HEPA filters based on the HEPA design are projected to be no greater than 0.3 microns. Particles around 1 micron (and less) are expected to have a very low terminal velocity and are effectively suspended in air, indicating particles passing through the HEPA filters (0.3 microns) will behave similarly. A single particle size of 1 micron will be assumed to be representative for all pure particles released from the stacks because of the use of HEPA filtration. In addition, a particle size of 2.5 microns will be modeled to represent the transport of particle-bound constituents. With regard to partitioning of particle-bound constituents, the particle size in the desert environment would dominate any particle size from the stack. Particle-bound constituents would disassociate from particulates in the stack gas, and reassociate with the natural airborne particulates in the local environment (see CCN 194345). This approach to air dispersion modeling is premised by the following assumptions:

- There is sufficient 2.5 micron ambient particles to accommodate the estimated release of particle-bound constituents (for adsorption and transport purposes)
- The pure particulates released from the stack do not have a predisposition to agglomerate into larger particles as suggested for particle-bound constituents (constituents with $F_v \leq 0.05$ are treated as particulates - modeled as 1 micron)
- The vapor phase dispersion and deposition is not affected by the stack particle size

6.1.4 Model Output

Modeled output is provided on a stack-by-stack basis for each air modeling receptor (node) evaluated. This information will provide the means to understand the relative risks of each source and helps facilitate the management of risks. The output will also identify applicable CALPUFF grids used to evaluate depositions across a particular area (such as a water body, Gable Mountain, or riparian area). The locations of the air modeling receptors used in the risk assessment are shown graphically with designations indicating whether the node represents an air concentration or deposition value. Complete files of all the air modeling projects (including input files and output files) will also be provided in run-ready electronic format.

6.1.4.1 Chronic Output

Chronic output from the WTP, to be evaluated in the risk assessment, will be based on the annual average ambient air concentrations and deposition rates for each COPC and ROPC at each exposure location, as calculated by the CALPUFF model. The annual average concentrations and deposition rates will be modeled for the period of 1 January 2002 to 31 December 2006 using the available MM5 and Hanford surface meteorological data.

6.1.4.2 Acute Output

The acute output from the WTP, to be evaluated in the risk assessment, will be based on the highest one-hour average air concentrations, as required by EPA guidance (EPA 2005), for each COPC and ROPC at each exposure location, as calculated by the CALPUFF model. The use of one-hour average air

concentrations is to support the analysis of worst-case acute effects in the risk assessment. An acute inhalation scenario is recommended by EPA (2005) because it is possible for air concentrations of COPCs to significantly exceed the annual average concentration for a brief period of time and, thus, result in acute effects to receptor populations via inhalation. Because the acute effects are only due to direct inhalation, deposition rates are not important in determining the acute risk. Concentrations in soil and other media reflect long-term deposition of COPCs and ROPCs. The long-term cumulative concentration in these media will be greater than the concentration resulting from any single acute event. Therefore, the acute exposure scenario is only applicable to the inhalation pathway.

The highest one-hour average concentration will be calculated for the worst-case hour (that is, the hour with the meteorological conditions that result in the highest concentration). Acute emissions estimates include process upset and fugitive emissions in addition to normal stack emissions as described in Section 5. Acute emissions-modeling does not include accidental (i.e., catastrophic) releases. Because the concentrations required to cause acute radiation effects due to external exposures would only result from an accident scenario, this event is not considered in the acute scenario.

6.1.4.3 Exposure Point Concentrations

Exposure point concentrations (EPC) used for estimating doses of COPCs and ROPCs depend on the location of the receptor exposure. The location of the various receptor populations identified for the quantitative risk assessment will correspond to the receptor exposure grids defined during air dispersion modeling. These receptor grids represent key locations on and off the Hanford site (see Section 7.1.1) where a receptor is exposed to contaminates via a pathway specific to the receptor's exposure scenario. Emissions will be modeled separately for each WTP facility (PT, LAW, and HLW). The individual flues associated with each of the facility stacks (which are in actuality structural steel lattices that support the individual flues for that facility) will be combined and modeled as three separate stacks. There are nine air model species possible from each facility stack:

- Unitized yearly air concentration from vapor phase, *Cyv* (in $\mu g \cdot s/g \cdot m^3$)
- Unitized yearly air concentration from particle phase (modeled as 1 micron diameter particles), Cyp_1 (in $\mu g \cdot s/g \cdot m^3$)
- Unitized yearly air concentration from particle phase (modeled as 2.5 micron diameter particles), $Cyp_{2.5}$ (in $\mu g \cdot s/g \cdot m^3$)
- Unitized yearly average dry deposition from vapor phase, *Dydv* (in $s/m^2 \cdot yr$)
- Unitized yearly average dry deposition from particle phase (modeled as 1 micron diameter particles), $Dydp_1$ (in $s/m^2 \cdot yr$)
- Unitized yearly average dry deposition from particle phase (modeled as 2.5 micron diameter particles), $Dydp_{2.5}$ (in $s/m^2 \cdot yr$)
- Unitized yearly average wet deposition from vapor phase, *Dywv* (in $s/m^2 \cdot yr$)
- Unitized yearly average wet deposition from particle phase (modeled as 1 micron diameter particles), $Dywp_1$ (in $s/m^2 \cdot yr$)
- Unitized yearly average wet deposition from particle phase (modeled as 2.5 micron diameter particles), $Dywp_{2.5}$ (in $s/m^2 \cdot yr$)

Vapor and particulate transport, concentration, and deposition are modeled independently. As described in Section 6.1.3.2, vapors will be represented by their respective model species, particulates will be

represented by the 1 micron particles, and particle-bound constituents will be represented by 2.5 micron particles. Air concentrations and wet- and dry-deposition rates for particle-bound constituents are the sum of their respective vapor and particle fractions at a given location. As discussed in Section 5.2, the vapor and particle fractions for particle-bound constituents are determined from a constituent's unique F_v value. By multiplying the modeled vapor concentration or deposition value by F_v, the respective vapor portion of a particle-bound constituent concentration or deposition is estimated. Likewise, by multiplying the unitized 2.5 micron particle concentration or deposition value by 1-F_v, the respective particle-bound portion of the constituent concentration or deposition is estimated. The vapor and particle-bound portions of a particle-bound constituent are then summed to estimate the total constituent concentration or deposition. A complete list of F_v values for each COPC and ROPC is included in Supplement 4 of this work plan.

There are a total of 27 possible maximum concentration and deposition values for each receptor exposure grid (3 stacks, each with 3 vapor phases [*Cyv*, *Dydv*, *Dywv*] and 3 particle phases, in either 1- or 2.5-micron sizes [Cyp_1, $Dydp_1$, $Dywp_1$, $Cyp_{2.5}$, $Dydp_{2.5}$, $Dywp_{2.5}$]) for each year of the air model run. It is not practical to assume a receptor can be simultaneously living at up to 27 different points within a receptor exposure grid. Some degree of simplification is used to combine concentration and deposition values while still preserving conservatism in the derived EPC.

Data produced from the CALPUFF was evaluated for basic statistical quantities, distribution, outliers, and spatial distribution in order to determine an appropriate value for use as input to the WTP environmental risk assessment (24590-WTP-RPT-ENV-13-001). The results of this evaluation indicated a high degree of non-normality in the data distribution with multiple outliers. This is of particular concern in large receptor exposure grids where the probability of exposure at a single discrete location is less probable than at a smaller, localized receptor grid. As a result, it was concluded that the exposure point concentration values from the CALPUFF modeling for input to the environmental risk assessment should be the 90th percentile values for large grids, namely the offsite receptor grid. For smaller receptor grids (onsite maximum, Columbia River, and Gable Mountain) the maximum discrete values for air concentration and deposition (as applicable to the exposure scenario) are appropriate as a means of bounding exposures at those locations while simplifying data selection. For the very large hunter/gatherer areas (where average exposures are of concern) the distribution-free 95 % upper confidence limit of the median provides a sufficiently conservative estimate of air concentration and deposition. This approach ensures sufficient conservatism without misrepresenting potential exposures due to a highly improbable exposure to extreme deposition and air concentrations.

In summary, the following CALPOST results will serve as inputs to the risk assessment:

- Onsite maximum, Columbia River, and Gable Mountain receptor grids: maximum discrete air concentration and deposition values (as applicable to the exposure scenario, without regard to multiple locations) of all modeled species (all years/grid points)
- Offsite receptor grid: 90th percentile of the air concentration and deposition values of all modeled species (all years/grid points)
- Hunter/gatherer receptor grid: 95 % upper confidence limit of the median (distribution-free) of air concentration and deposition values of all modeled species (all years/grid points)

In order to determine the appropriate incremental cancer risk or toxic effect, each contaminant must be classified as either a carcinogen or noncarcinogen. For this risk assessment, a contaminant is classified as a carcinogen if a cancer slope factor (*CSF*) is available or if the EPA classification is A, B1, B2, or C (see

Section 7.2.1.1 for more details on *CSF*s and the EPA classifications for contaminants; also, note that all ROPCs are classified as carcinogens). A COPC is classified as a noncarcinogen if an oral or inhalation reference dose (*RfD*) is available (see Section 7.2.1.1 for more details on *RfD*s) or if no *CSF* or *RfD* is available. Note that only COPCs have *RfD*s; ROPCs do not have *RfD*s (however, the stable isotope of ROPCs can have *RfD*s and they are evaluated for both carcinogenic and noncarcinogenic effects). Some contaminants may be classified as both a carcinogen and a noncarcinogen (if they have both a *CSF* and a *RfD*); in this case, both the carcinogenic and the noncarcinogenic will be used in the risk assessment. Once the EPC of a constituent has been computed, the corresponding receptor dose and health impacts are assessed as described in subsequent portions of this work plan.

6.2 Soil Accumulation Modeling

Concentrations of COPCs and ROPCs in soil will be estimated from deposition rates of vapor, and particle phases predicted by the air dispersion modeling. The particle and vapor fractions of particle-bound constituents will be recombined at each deposition location and handled as a single, particle-bound constituent in the risk modeling steps. For the SLRA, deposition is assumed to occur for the potential operating lifespan of the facility (40 years). The COPC and ROPC concentrations in soil will be calculated for vapor, particle, and particle-bound phases. The emissions report, included in Supplement 2 of this work plan, specifies the COPC and ROPC phases along with the constituent-specific F_v parameter values. Both wet and dry deposition of particles, particle-bound, and vapor constituents will be considered in the soil modeling.

Various equations are used in the soil accumulation modeling. Some parameter values used in this modeling are functions of other parameters, which are functions of yet other parameters. To avoid confusion, the primary equations for soil accumulation modeling appear in Section 6.2; supporting/intermediary equations appear in Appendix A. A cross-reference to these supporting/intermediary equations is presented in this section.

The EPA guidance (EPA 2005) for calculating emissions concentrations in soil includes terms that account for loss of COPCs by several mechanisms, including:

- Degradation (biotic and abiotic)
- Leaching
- Surface runoff
- Volatilization
- Soil erosion

Although not mentioned in EPA guidance, radiological decay for ROPCs is comparable to degradation for COPCs and is also considered as a soil loss mechanism in the soil modeling. Therefore, all five soil-loss mechanisms will be considered as possible soil-loss mechanisms in the calculation of soil concentrations. Equations to calculate the soil loss mechanisms are located in Appendix A.

A number of soil loss parameters are dependent on the available water, calculated as ($P+I-RO-E_v$), which is related to precipitation (P), irrigation (I), surface runoff (RO), and evapotranspiration (E_v) in the Hanford site area. Climate in the region results in greater evapotranspiration than precipitation (DOE 1997). Some areas are irrigated; however, the high evapotranspiration and scarce water resources minimize the potential for runoff due to excessive irrigation. Therefore, neither natural precipitation nor

irrigation provides adequate water to generate surface runoff, and these processes should have a negligible effect on the concentration of COPCs and ROPCs in soil.

All six soil-loss mechanisms are possible, with varying degrees of influence on the soil modeling. However, based on the discussion above on available water, the calculation of soil concentrations is likely to include soil loss due to degradation (biotic and abiotic), radiological decay, leaching, and volatilization. The calculation of soil concentrations is not likely to include soil loss due to surface runoff and soil erosion. For completeness, the equations presented below and in Appendix A will include all six soil-loss mechanisms.

Because some of the soil loss mechanisms are calculated with depth-specific parameters, the total soil loss across all soil loss mechanisms shown above is depth-specific. For this risk assessment, soil concentrations are determined for three specific soil depths: tilled soil, untilled soil, and root zone soil.

The tilled soil condition assumes that deposited emissions are mixed to a tilled depth of 20 cm for plants grown in domestic scenarios (for example, produce grown by a farmer and grain and silage grown for consumption by domestic animals).

The untilled soil condition assumes emissions are deposited on the top 2 cm of soil and stay there (i.e., no mixing occurs). Untilled soil concentrations are used to calculate direct exposure to soil (such as ingestion) by human and ecological receptors, but the untilled soil depth of 2 cm is considered too shallow to estimate plant concentrations for consumption by human and ecological receptors (i.e., no plant concentrations are modeled from the untilled soil concentrations).

The root-zone soil depth is where deposited emissions are assumed to be mixed to a root-zone depth of 15 cm for exposure of invertebrates and wild plants collected by American Indian receptors and forage ingested by domestic and wild animals. Use of root zone soil concentrations for these pathways is conservative because:

- Mixing will occur naturally as a result of plant roots and digging by worms, insects, and larger animals.
- Plant roots and soil invertebrates will exist below 2 cm and, therefore, be exposed to clean soil below this depth.

For this risk assessment, the time period over which deposition may occur (denoted as tD) is 40 years. This represents the time period of WTP operation, during which emissions and consequential deposition occur. For soil modeling, the time period at the beginning of the WTP operation is from 0 to 40 years. Receptor exposures are assumed to occur from year T_1 (when the receptor arrives at the exposure location) to T_2 (when the receptor departs from the exposure location). Receptors that arrive at the exposure location before WTP shutdown ($T_1 < tD$) are considered part of the current exposure scenario. Receptors that arrive at the exposure location at the time of or subsequent to WTP shutdown ($T_1 \geq tD$) are considered part of the future exposure scenario.

As with EPC estimation, in order to apply the appropriate equation for soil modeling, each contaminant must be classified as either a carcinogen or noncarcinogen. This is because the exposure or dose averaging time differs depending upon whether the constituent toxicity values are based on average doses (i.e., incidence of cancer) or threshold doses (i.e., health degradation such as nervous system damage). The effective soil concentration used for computing receptor dose is a function of the receptor averaging

time, so constituent carcinogenicity is a necessary consideration in soil concentration modeling. Some contaminants may be classified as both a carcinogen and a noncarcinogen (if they have both a *CSF* and a *RfD*); in this case, both the carcinogenic soil model and the noncarcinogenic soil model will be used to estimate soil concentrations. Because carcinogenic risk is averaged over the lifetime of an individual (AT_C), the soil concentration averaged over the exposure duration (represented by *Cs*) is used for dose assessment for carcinogenic compounds. Because the hazard quotient associated with noncarcinogenic constituents is based on a threshold dose rather than a lifetime exposure, the highest annual average soil concentration (Cs_{tD}) occurring during the exposure duration period is used for dose assessment for noncarcinogenic constituents. Cs_{tD} typically occurs at the end of the operating life of the emission source (EPA 2005). Note that because risks for noncarcinogens are based on a threshold dose, receptor exposure averaging time (AT_N) is limited to the exposure duration (*ED*).

Eight soil equations are provided below for the various scenarios encountered (i.e., the combinations of whether the contaminant is carcinogenic or noncarcinogenic, whether the soil loss constant [represented by the variable *ks*] is a positive value [meaning there is soil loss] or zero [meaning there is no soil loss], and whether exposure occurs during or after the period of emission/deposition).

The following equations are used for calculating soil concentrations, depending on whether the COPC is carcinogenic or noncarcinogenic. Parameters for soil concentration equations are defined in text that follows each equation. Supporting equations are shown in Appendix A. The equations and parameters are from EPA's HHRAP.

To compute the soil concentration, the soil deposition term (*Ds*) must first be computed. The equation to calculate *Ds* is:

$$Ds = \frac{Q \cdot CF}{Z_s \cdot BD} \cdot \left[F_v \cdot (Dydv + Dywv) + (Dydp + Dywp) \cdot (1 - F_v)\right] \qquad \text{(Table B-1-1 in HHRAP)}$$

Where:

- Ds = deposition term to soil (mg/kg·yr). *Ds* is constituent-specific, site-specific, and depth-specific.
- Q = constituent-specific emission rate (g/s for COPCs, Ci/s for ROPCs). *Q*, obtained from calculations after the air dispersion modeling (that is, the unitized emission rate of 1 g/s or 1 Ci/s multiplied by the estimated COPC/ROPC specific emission rate), is constituent-specific, site-specific, and flue stack-specific.
- CF_1 = units conversion factor of 100 ($mg \cdot m^2/kg \cdot cm^2$) for COPCs. For ROPCs, the conversion factor is 1×10^8 ($pCi \cdot m^2/Ci \cdot cm^2$)
- F_v = fraction of COPC constituent air concentration in vapor phase (unitless). F_v is constituent-specific and ranges from 0 to 1, and is shown in Supplement 4. Constituents with a vapor fraction less than 0.05 are modeled as entirely particulate with an F_v value of 0 (CCN 097844). When F_v is not available, it is empirically derived for most constituents (except metals and some mercury compounds) using Eqs. A-2-1 and A-2-2 (when appropriate) in the HHRAP.
- $Dydv$ = unitized yearly average dry deposition from vapor phase ($s/m^2 \cdot yr$). *Dydv*, from the air dispersion modeling, is site-specific and stack-specific. If no *Dydv* value exists for a constituent, the model uses $Dydv = 0$ $s/m^2 \cdot yr$.

Dywv = unitized yearly average wet deposition from vapor phase (s/m^2·yr). *Dywv*, from the air dispersion modeling, is site-specific and stack-specific. If no *Dywv* value exists for a constituent, the model uses *Dywv* = 0 s/m^2·yr.

Dydp = unitized yearly average dry deposition from particle phase (s/m^2·yr). *Dydp*, from the air dispersion modeling, is site-specific and stack-specific. If no *Dydp* value exists for a constituent, the model uses *Dydp* = 0 s/m^2·yr.

Dywp = unitized yearly average wet deposition from particle phase (s/m^2·yr). *Dywp*, from the air dispersion modeling, is site-specific and stack-specific. If no *Dywp* value exists for a constituent, the model uses *Dywp* = 0 s/m^2·yr.

Z_s = soil mixing zone depth (cm). Z_s is site-specific. Three different values (depths) are used for Z_s: untilled soil (2 cm), root-zone soil (15 cm), and tilled soil (20 cm).

BD = soil bulk density (g/cm^3). A site-specific value of 1.3 g/cm^3 (Halvorson et al. 1998) is used.

The soil term equation combines the unitized stack deposition rate with the mass flow rate of constituents from the stack and the quantity of soil to arrive at a time-dependent soil concentration. For constituents that undergo soil loss ($ks > 0$), this concentration is increasing due to continued stack deposition during WTP operations, while simultaneously decreasing due to soil loss. After WTP shutdown, constituent accumulation in the soil stops and the loss continues. The soil loss is an exponential function of the soil deposition term. In instances where there is no soil loss ($ks = 0$), soil concentration is directly proportional to the rate of deposition and time, and reaches a maximum when deposition ceases (at time *tD*).

As previously discussed, the hazard quotient associated with noncarcinogenic constituents is based on a threshold dose rather than a lifetime exposure. Per guidance in the HHRAP, the highest annual soil concentration (Cs_{tD}) occurring during the exposure duration period is used for dose assessment for noncarcinogenic constituents. For this to be the case, it is assumed that all receptors exposed in the current timeframe are present at time *tD* when soil accumulation is at a maximum. Likewise, it is assumed that all receptors exposed in the future timeframe are assumed to arrive at their respective exposure locations at time *tD*.

For noncarcinogenic constituents, when the soil loss is zero or unknown, current and future exposure scenarios are:

$RfD > 0$

$ks = 0$

$T_1 < tD$ or $tD < T_1$

$$Cs_{tD} = Ds \cdot tD \qquad \text{(modified Eq. 5-1B in HHRAP)}$$

For noncarcinogenic constituents, when the soil loss is greater than zero, current and future exposure scenarios are as follows:

$RfD > 0$

$ks > 0$

$T_1 < tD$ or $tD < T_1$

$$Cs_{tD} = \frac{Ds \cdot \left[1 - e^{(-ks \cdot tD)}\right]}{ks} \qquad \text{(Eq. 5-1E in HHRAP)}$$

where:

- Cs_{tD} = maximum soil concentration; occurs at time tD (mg/kg soil).
- Ds = deposition term to soil (mg/kg·yr). Ds is constituent-specific, site-specific, and depth-specific.
- ks = overall soil loss constant due to all processes (yr^{-1}).
- T_1 = the time at the start of exposure (yr).
- T_2 = the time at the end of exposure (yr).
- tD = time period over which deposition occurs (time period of WTP operation) (yr). A value of $tD = 40$ yr is used as the operating lifetime of the WTP.
- e = base of the natural logarithm (unitless). $e = \sum_{i=0}^{\infty} \frac{1}{i!} \approx 2.718282$.

Because carcinogenic risk is averaged over the lifetime of an individual, the average soil concentration (represented by Cs) over the exposure duration (from T_1 to T_2) is used for dose assessment for carcinogenic compounds. Because soil concentrations may require many years to reach steady state, the equations used to calculate the average soil concentration over the period of receptor exposure are derived by integrating the instantaneous soil concentration equation over the period of receptor exposure and dividing the result by the exposure period (refer to Appendix A). Furthermore, during the time period following the cessation of WTP emissions (e.g., future scenarios), soil concentrations decline gradually due to various soil loss mechanisms and may require many more years to reach steady state. Again, integrating the instantaneous soil concentration equation over the period of exposure and dividing by the exposure period will yield an average exposure concentration for the receptor. Because the function for soil concentration changes from accumulation to degradation when emissions cease, exposures before and after WTP shutdown must be distinguished for carcinogens.

For carcinogenic constituents, when the soil loss is zero or unknown, current exposures scenarios:

$CSF > 0$
$ks = 0$
$T_1 < T_2 = tD$

$$Cs = \frac{Ds \cdot (tD + T_1)}{2} \qquad \text{(modified Eq. 5-1B in HHRAP)}$$

For carcinogenic constituents, when the soil loss is greater than zero, current exposures scenarios:

$CSF > 0$
$ks > 0$
$T_1 < T_2 = tD$

$$Cs = \frac{Ds}{ks \cdot (tD - T_1)} \cdot \left(\left(tD + \frac{e^{-ks \cdot tD}}{ks} \right) - \left(T_1 + \frac{e^{-ks \cdot T_1}}{ks} \right) \right) \qquad \text{(Eq. 5-1C in HHRAP)}$$

For carcinogenic constituents, when the soil loss is zero or unknown, future exposures scenarios:

$CSF > 0$
$ks = 0$
$T_1 = tD < T_2$

$$Cs = Ds \cdot tD \qquad \text{(modified Eq. 5-1B in HHRAP)}$$

For carcinogenic constituents, when the soil loss is greater than zero, future exposures scenarios:

$CSF > 0$
$ks > 0$
$T_1 = tD < T_2$

$$Cs = \frac{Cs_{tD}}{ks \cdot (T_2 - tD)} \cdot \left(1 - \frac{e^{-ks \cdot (T_2 - tD)}}{ks} \right) \qquad \text{(modified Eq. 5-1C in HHRAP)}$$

where:

Cs	=	average soil concentration; maximum occurs at time tD (mg/kg soil or pCi/g).
Cs_{tD}	=	soil concentration at time tD ($Cs_{tD} = Ds \cdot (1 - e^{-ks \cdot tD})/ks$), assuming no soil loss (mg COPC/kg soil).
Ds	=	deposition term to soil (mg/kg-yr). Ds is constituent-specific, site-specific, and depth-specific.
ks	=	overall soil loss constant due to all processes (yr^{-1}).
T_1	=	the time at the start of exposure (yr).
T_2	=	the time at the end of exposure (yr).
tD	=	time period over which deposition occurs (time period of WTP operation) (yr). A value of $tD = 40$ yr is used as the operating lifetime of the WTP.
e	=	base of the natural logarithm (unitless). $e = \sum_{i=0}^{\infty} \frac{1}{i!} \approx 2.718282$.

If the exposure period spans the period of operation and a period of time subsequent to operations, the average soil concentration will include exposure to soil during WTP operations (the period of contaminant accumulation), and exposure to soil after WTP operation (during contaminant degradation).

For carcinogenic constituents, when the soil loss is zero or unknown, exposures spanning current and future scenarios:

$CSF > 0$
$ks = 0$
$T_1 < tD < T_2$

$$Cs = \frac{Ds}{2 \cdot (T_2 - T_1)} \cdot \left(2 \cdot T_2 \cdot tD - tD^2 - T_1^2\right) \qquad \text{(modified Eq. 5-1B in HHRAP)}$$

For carcinogenic constituents, when the soil loss is greater than zero, exposures spanning current and future scenarios:

$CSF > 0$
$ks > 0$
$T_1 < tD < T_2$

$$Cs = \frac{\left(\frac{Ds \cdot tD - Cs_{tD}}{ks}\right) + \left(\frac{Cs_{tD}}{ks}\right) \cdot \left(1 - e^{-ks \cdot (T_2 - tD)}\right)}{(T_2 - T_1)} \qquad \text{(Eq. 5-1D in HHRAP)}$$

where:

- Cs = average soil concentration; maximum occurs at time tD (mg/kg soil or pCi/g).
- Cs_{tD} = soil concentration at time tD ($Cs_{tD} = Ds \cdot (1\text{-}e^{-ks \cdot tD})/ks$), assuming no soil loss (mg/kg soil or pCi/g).
- Ds = deposition term to soil (mg/kg·yr). Ds is constituent-specific, site-specific, and depth-specific.
- ks = overall soil loss constant due to all processes (yr^{-1}).
- T_1 = the time at the start of exposure (yr).
- T_2 = the time at the end of exposure (yr).
- tD = time period over which deposition occurs (time period of WTP operation) (yr). A value of $tD = 40$ yr is used as the operating lifetime of the WTP.
- e = base of the natural logarithm (unitless). $e = \sum_{i=0}^{\infty} \frac{1}{i!} \approx 2.718282$.

Figure 6-8 shows the exposure timing of the receptors discussed in Section 7 with respect to instantaneous and running average soil concentration levels of a hypothetical COPC. The figure illustrates the conservative assumption regarding the timing of receptor exposures. The figure shows two examples of soil concentration (with and without soil loss) to illustrate the time dependence of soil concentrations relative to WTP operations. The figure shows the time of increase and subsequent leveling off of the instantaneous soil concentration used for noncarcinogen assessment, as represented by the blue line. No known soil loss occurs in this case so the concentration is represented by a straight line that reaches a maximum, *CstD*, at the cessation of operations with no post-operations losses. The green line

illustrates the instantaneous soil concentration in the soil as deposition occurs simultaneous with soil loss, again with a maximum soil concentration at the end of operations. The figure also shows the average soil concentration (for example, carcinogen assessment) without and with soil loss occurring. The magenta line mimics the blue line, only it has half the magnitude because it represents an average concentration over time. The red line shows gradual accumulation of a contaminant in the soil as deposition occurs, with simultaneous soil loss, and post-operation soil loss. Because it represents an average exposure concentration from time = 0, its decrease after the cessation of operations is much more gradual than the instantaneous soil concentration (with loss). As applied, the equations above are used to determine the maximum potential exposure concentration of each receptor. Appendix A of this document provides additional detail including derivation of the equations above.

6.3 Surface Water Accumulation Modeling

Concentrations of COPCs and ROPCs in surface water will be estimated from EPCs described in Section 6.1.4.3 as derived from the Columbia River air modeling exposure grid (see Section 6.1.2.6). For this risk assessment, deposition is assumed to occur for the potential operating lifespan of the facility (40 years). The COPC and ROPC concentrations in surface water (water in a pond, stream, river, or other water body, that is, the Columbia River) are calculated for vapor, particle, and particle-bound phases. The emissions report, included in Supplement 2 of this work plan, specifies the COPC and ROPC phases along with the constituent-specific F_v parameter values. Both wet and dry deposition of particles, particle-bound, and vapor constituents will be considered in the surface water modeling. Note that for evaluation of future exposure scenarios (after cessation of emissions), air concentration and deposition rates are zero; thus, no surface water accumulation occurs.

Various equations are used in the surface water accumulation modeling. Some parameter values used in this modeling are functions of other parameters, which are functions of yet other parameters. To avoid confusion, the primary equations for surface water accumulation modeling appear in Section 6.3; supporting/intermediary equations appear in Appendix A. A cross-reference to these supporting/intermediary equations is presented in this section.

The COPC and ROPC concentrations in surface water will be calculated for the drinking water, dermal contact, and fish ingestion pathways in the human health risk assessment, and the direct contact (aquatic life and fish) and indirect ingestion pathways for ecological receptors. The COPC and ROPC surface water concentrations are determined after considering the following mechanisms loaded into the water column (i.e., a volume of water of uniform horizontal cross-section that extends from the surface to the bottom of the water body):

- Direct deposition
- Direct diffusion of vapor phase COPCs and ROPCs into the surface water
- Runoff from impervious surfaces within the watershed (that is, the area potentially contributing water to the Columbia River)
- Runoff from pervious surfaces within the watershed
- Soil erosion over the total watershed
- Chemical, biological, or radiological transformation of compounds within the surface water body

As noted previously in Section 6.2, evapotranspiration exceeds precipitation in the Hanford site area, resulting in insufficient water available to cause significant erosion or runoff of COPCs and ROPCs

(since evapotranspiration exceeds precipitation, there is no water to run off; the water goes back up into the air). Thus, surface runoff and soil erosion are expected to be insignificant soil loss mechanisms and insignificant surface water loading mechanisms. Since surface runoff and erosion to the Columbia River are assumed to be negligible, a watershed area is provided for information, but not used. Also, since the maximum constituent concentrations in surface water and sediment will be used as inputs for these pathways, a surface water area (or "effective" area) is provided for information, but will not be used. Therefore, surface runoff and soil erosion will not be included as surface water loading mechanisms unless they are included as soil loss mechanisms (note that EPA 2005 recommends that the soil loss due to soil erosion should not be included in the soil accumulation modeling). Also, as noted in EPA 2005, the chemical, biological, or radiological transformation of compounds within the surface water body should not be included as a load to the surface water body because of limited data and uncertainty associated with this mechanism.

Therefore, contaminant loading to surface water for the PRA will be from direct deposition and vapor phase dry deposition diffusion. For completeness, the equations presented below include all potential surface water loading mechanisms.

The COPCs and ROPCs in surface water will be estimated using equations presented below. These equations are from EPA 2005; however, because this guidance does not address ROPCs, minor changes (e.g., the use of unit conversion factors) have been made to these equations to address ROPCs. Supporting and intermediate equations are presented in Appendix A of this work plan. Values for the Hanford-specific and site-specific parameters used in surface water modeling are presented in Table 6-3. Values for the COPC- and ROPC-specific parameters are presented in Supplement 4.

The site-specific equation used to quantify the total COPC and ROPC load to the surface water body is:

$$L_T = L_{DEP} + L_{DIF} + L_{RI} + L_R + L_E \qquad \text{(Eq.5-28 in HHRAP)}$$

where:

L_T = total COPC or ROPC load to the water body, including deposition, runoff, and erosion (g/yr for COPCs and Ci/yr for ROPCs). Note that because there are three facility stacks, L_T is calculated for each individual stack before summing across all three stacks to obtain a total direct deposition load to the water body.

L_{DEP} = total (wet and dry) particle-phase and total (wet and dry) vapor-phase direct deposition load to water body (g/yr for COPCs and Ci/yr for ROPCs). L_{DEP} is calculated in Eq. 5-29 of the HHRAP.

L_{DIF} = vapor-phase dry deposition diffusion load to water body (g/yr for COPCs and Ci/yr for ROPCs). L_{DIF} is calculated in Eq. 5-30 of the HHRAP.

L_{RI} = runoff load from impervious surfaces (g/yr for COPCs and Ci/yr for ROPCs). L_{RI} is calculated in Eq. 5-31 of the HHRAP, but is assumed to equal zero for this risk assessment.

L_R = runoff load from pervious surfaces (g/yr for COPCs and Ci/yr for ROPCs). L_{RP} is calculated in Eq. 5-32 of the HHRAP, but is assumed to equal zero for this risk assessment.

L_E = soil erosion load to the surface water body (g/yr for COPCs and Ci/yr for ROPCs). L_E is calculated in Eq. 5-33 of the HHRAP, but is assumed to equal zero for this risk assessment.

Once the total load to the water body (L_T) is estimated, the total water body COPC or ROPC concentration (C_{wtot}) will be calculated. This total water body concentration is subsequently used to estimate the total concentration in the water column (see below), as well as the concentration adsorbed to the bed sediment (see Section 6.4). The equation used to estimate the total water body concentration for COPCs is:

$$C_{wtot} = \frac{L_T}{Vf_x \cdot f_{wc} + k_{wt} \cdot A_W \cdot (d_{wc} + d_{bs})} \qquad \text{(Eq. 5-35 in HHRAP)}$$

Where:

C_{wtot} = total water body COPC or ROPC concentration, including the water column and bed sediment (mg/L for COPCs and pCi/L for ROPCs). Note that for ROPCs, a unit conversion factor of 1×10^9 pCi·m^3/Ci·L must be applied.

L_T = total COPC or ROPC load to the water body (g/yr for COPCs and Ci/yr for ROPCs). L_T is calculated in Eq. 5-28 in the HHRAP.

Vf_x = average annual volumetric flow rate through the water body (m^3/yr). Vf_x is site-specific. A value of Vf_x = 1.05961E+11 m^3/yr (PNNL 2006, based on 3360 m^3/s for Priest Rapids Dam) (Table 6-3).

f_{wc} = fraction of the total water body COPC or ROPC concentration in the water column (unitless). f_{wc} ranges from 0 to 1 and is calculated in Eq. 5-36A in the HHRAP.

k_{wt} = overall total water body COPC or ROPC dissipation rate constant (1/yr). k_{wt} is calculated in Eq. 5-38 in the HHRAP.

A_w = average annual water body surface area (m^2). A value of A_w = 3.642E+07 m^2 is used based on all of the Columbia River within the Hanford Site boundary (PNNL 2006) (Table 6-3 and Figure 3-1).

d_{wc} = average annual depth of the water column (m). An estimated value of d_{wc} = 28.4 ft (8.66 m) (modeling data from Columbia Basin Research 2000, Hanford Reach full pool depth at the downstream end of the segment) is used (Table 6-3).

d_{bs} = depth of the upper benthic sediment layer (m). The recommended default value of 0.03 m (HHRAP Section 5.4.7) is used (Table 6-3).

Once the total water body COPC and ROPC concentration (C_{wtot}) is estimated, the total COPC and ROPC concentration in the water column (C_{wctot}) will be calculated. This total concentration in the water column will subsequently be used to estimate the dissolved-phase water concentration (see below) and to model direct contact (aquatic life and trout) and water ingestion exposure in the ecological risk assessment. The total concentration in the water column includes both dissolved COPCs and ROPCs and COPCs and ROPCs sorbed to suspended solids. The equation used to estimate the total concentration in the water column is:

$$C_{wctot} = f_{wc} \cdot C_{wtot} \cdot \left(\frac{d_{wc} + d_{bs}}{d_{wc}} \right) \qquad \text{(Eq. 5-45 in HHRAP)}$$

where:

C_{wctot} = total COPC or ROPC concentration in the water column (mg/L for COPCs and pCi/L for ROPCs)

f_{wc} = fraction of the total water body COPC or ROPC concentration in the water column (unitless). f_{wc} ranges from 0 to 1 and is calculated in Eq. 5-36A in the HHRAP.

C_{wtot} = total water body COPC or ROPC concentration, including the water column and bed sediment (mg/L for COPCs and pCi/L for ROPCs). C_{wtot} is calculated in Eq. 5-35 in the HHRAP

d_{wc} = average annual depth of the water column (m). An estimated value of d_{wc} = 28.4 ft (8.66 m) (modeling data from Columbia Basin Research 2000, Hanford Reach full pool depth at the downstream end of the segment) is used (Table 6-3).

d_{bs} = depth of the upper benthic sediment layer (m). The recommended default value of 0.03 m (HHRAP Section 5.4.7 is used (Table 6-3).

Once the total COPC and ROPC concentration in the water column (C_{wctot}) is estimated, the dissolved phase COPC and ROPC water concentration (C_{dw}) will be calculated. The equation for this concentration is:

$$C_{dw} = \frac{C_{wctot}}{1 + Kd_{sw} \cdot TSS \cdot CF}$$ (Eq. 5-46 in HHRAP)

where:

C_{dw} = dissolved-phase water concentration (mg/L for COPCs and pCi/L for ROPCs)

C_{wctot} = total COPC or ROPC concentration in the water column (mg/L for COPCs and pCi/L for ROPCs). C_{wctot} is calculated in Eq. 5-45 in the HHRAP.

Kd_{sw} = suspended sediments/surface water partition coefficient (L/kg). Kd_{sw} is shown in Supplement 4. If no Kd_{sw} value exists for an organic constituent, then Kd_{sw} is estimated using Eq. A-2-11 in the HHRAP and a default $f_{oc,sw}$ = 0.075 (fraction of organic carbon in suspended sediments, HHRAP Section A2-2.10) provided the constituent K_{oc} value (soil organic carbon-water partition coefficient) is known. If Kd_{sw} is not available and cannot be estimated, a value of 0 L/kg is used for Kd_{sw} to estimate C_{dw}.

TSS = total suspended solids concentration (mg/L). Since a site-specific value is not available, a default value of 10 mg/L (HHRAP Section 5.7.4.1) is used (Table 6-3).

CF = units conversion factor of 1×10^{-6} (kg/mg)

The dissolved-phase COPC and ROPC water concentration (C_{dw}) will be used in the human health risk assessment as the source of drinking water, the source of water for the sweat lodge exposure pathway, and, depending on the constituent, for the modeling of fish concentrations (see Section 7.1.7.5). C_{dw} is used for the modeling of fish concentrations for all COPCs and ROPCs in the ecological risk assessment.

6.4 Sediment Accumulation Modeling

River sediment concentrations are modeled using the previously modeled total water body concentrations (see Section 6.3). Sediment concentrations are used in the ecological risk assessment (ERA) and to model fish concentrations for specific COPCs for the human health risk assessment (see Section 7.1.7.5).

Various equations are used in the sediment accumulation modeling. Some parameter values used in this modeling are functions of other parameters, which are functions of yet other parameters. To avoid confusion, the primary equations for sediment accumulation modeling appear in Section 6.4; supporting/intermediary equations appear in Appendix A. A cross-reference to these supporting/intermediary equations is presented in this section.

The equation for calculating COPC and ROPC concentrations sorbed to bed sediment is:

$$C_{sed} = f_{bs} \cdot C_{wtot} \cdot \left(\frac{Kd_{bs}}{\theta_{bs} + Kd_{bs} \cdot C_{BS}} \right) \cdot \left(\frac{d_{wc} + d_{bs}}{d_{bs}} \right) \qquad \text{(Eq. 5-47 in HHRAP)}$$

where:

- C_{sed} = COPC or ROPC concentration in bed sediment (mg/kg for COPCs and pCi/g for ROPCs). Note that a unit conversion factor of 1×10^{-3} kg/g is used for ROPCs.
- f_{bs} = fraction of total water body COPC or ROPC concentration in the benthic sediment. (unitless); f_{bs} ranges from 0 to 1 and is calculated in Eq. 5-36B in the HHRAP.
- C_{wtot} = total water body COPC or ROPC concentration, including the water column and bed sediment (mg/L for COPCs and pCi/L for ROPCs). C_{wtot} is calculated in Eq. 5-35 in the HHRAP.
- Kd_{bs} = bed sediment/sediment pore water partition coefficient (L/kg). Kd_{bs} is shown in Supplement 4. If no Kd_{bs} value exists for an organic constituent, then Kd_{bs} is estimated using Eq. A-2-12 in the HHRAP and a default $f_{oc,bs} = 0.04$ (fraction of organic carbon in bottom sediments, HHRAP Section A2-2.10), provided the constituent K_{oc} value (soil organic carbon-water partition coefficient) is known. If no Kd_{bs} value exists for a constituent, and if Kd_{bs} cannot be estimated, a value of 0 L/kg is used.
- θ_{bs} = bed sediment porosity ($L_{pore\ water}/L_{sediment}$). The recommended default value of 0.6 L/L (EPA 2005) is used (Table 6-3).
- C_{BS} = bed sediment concentration (g/cm^3). The recommended default value of 1 g/cm^3 (HHRAP Section 5.7.4.1) is used (Table 6-3).
- d_{wc} = average annual depth of water column (m). An estimated value of d_{wc} = 28.4 ft (8.66 m) (modeling data from Columbia Basin Research 2000, Hanford Reach full pool depth at the downstream end of the segment) is used (Table 6-3).
- d_{bs} = depth of upper benthic sediment layer (m). The recommended default value of 0.03 m (HHRAP Section 5.4.7) is used (Table 6-3).

6.5 Special Considerations for Mercury Modeling

Note that special equations for mercury modeling of each of these load parameters are stipulated in the HHRAP and provided in Appendix A. The HHRAP (EPA 2005) and the *Screening Level Ecological*

Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 1999, herein referred to as the SLERAP) assume that stack emissions contain a variable mix of elemental and divalent mercury, but no methyl mercury. These guidance sources state that mercury emissions are partitioned in the atmosphere in both the elemental (Hg^0) and divalent (Hg^{2+}) form, with part of the mercury going into the global cycle, and another part subject to inhalation or uptake in environmental media (soil, water, and plants), and it should be assumed that 48 % of the divalent mercury and 0.2 % of the elemental mercury is deposited. However, mercury has been detected in some tank waste sample analyses and dimethylmercury (DMHg) has been detected in tank headspace samples in very small quantities. Some DMHg may be present in the waste feed, and some could be generated in plant processes, resulting in non-zero concentrations in plant emissions.

In the RAWP, it is assumed that stack emissions of mercury will be in the elemental, divalent and dimethyl form. The emissions estimate provides emissions of non-methyl mercury and dimethyl mercury. The partitioning of non-methyl form of mercury into elemental and divalent forms will be performed according to the HHRAP. However, the assumption is made that DMHg emissions do not enter the global cycle, transform (into other forms) or decay, and that 100 % of the DMHg is available for inhalation and uptake by environmental media. This is a conservative approach because in all likelihood, a substantial portion of any DMHg emitted will become part of the global cycle. Likewise, by this approach, no credit is taken for decay, oxidation, or other transformation of DMHg in the atmosphere.

Per HHRAP guidance, it is assumed that 48 % of the non-methyl mercury emitted will be deposited (Appendix A, or equations in Table B-1-1 [land], and Tables B-4-8 through B-4-12 [surface water] of the HHRAP). A portion of the non-methyl mercury emissions is assumed to convert into a mono-methyl form through interaction with organic media upon deposition. It is assumed that methyl mercury (MHg) is formed only after deposition to soil or surface water. Per EPA guidance (EPA 2005 and 1999), it is assumed that the fraction of methyl mercury in dry soil is 2 % (Appendix A, or equations in Table B-1-1 in the HHRAP) and the fraction of methyl mercury in surface water is 15 % (HHRAP Table B-4-24). Note also that because there are three facility stacks, each load type will be calculated for each individual stack before summing across all three stacks to obtain a total load.

Figure 6-9 is an illustration summarizing the assumptions with regards to mercury partitioning.

6.6 Terrestrial Plant Accumulation Modeling

The models used to calculate concentrations of contaminants in plants consumed by both human and nonhuman receptors will be the same. The use of the same models for human and nonhuman receptors is based on previous stakeholder and tribal nations' requests. Plants, such as homegrown vegetables or wild produce, are consumed by humans and animals (e.g., as forage for browsing animals and as silage).

Various equations are used in the terrestrial plant accumulation modeling. Some parameter values used in this modeling are functions of other parameters, which are functions of yet other parameters. To avoid confusion, the primary equations for terrestrial plant accumulation modeling appear in Section 6.6; supporting/intermediary equations appear in Appendix A. A cross-reference to these supporting/intermediary equations is presented in this section.

The COPC and ROPC concentrations in plants will be estimated for aboveground produce and belowground produce. Aboveground produce will be exposed to particulate deposition (i.e., direct deposition onto the plant surfaces) and vapor phase contamination (i.e., air-to-plant transfer), as well as root uptake from soil and subsequent transfer to aboveground foliage. Aboveground plant parts are categorized

as protected (i.e., the plant structure prevents accumulation of contaminants through the deposition and air-to-plant pathways) and unprotected. For example, corn kernels are protected by husks. Protected plant parts will be limited in this evaluation to grain used as animal feed. All other plant parts for human and animal consumption will be considered unprotected (i.e., not physically shielded from deposition). Belowground produce will only be exposed to contaminants from the soil through root uptake.

Concentrations of COPCs and ROPCs in plants will be estimated using the equations presented below as recommended in the HHRAP. Plant modeling for carbon-14 and hydrogen-3 (tritium) are special cases, based on guidance from Regulatory Guide 1.109 (NRC 1977) and are discussed in Section 6.6.2. Note that for all COPCs and ROPCs except carbon-14 and tritium, concentrations for various types of plants (e.g., aboveground plant due to direct deposition, belowground plant due to root uptake) are modeled. For carbon-14 and tritium, a single "concentration in vegetation" is modeled and used in the subsequent risk assessment. Values for site-specific parameters used in plant modeling are located in Table 6-4, while values for the chemical-specific parameters are presented in Supplement 4.

6.6.1 Aboveground Plants/Direct Deposition

The equations used to estimate the aboveground plant concentration due to direct deposition are presented below. Special consideration is given to modeling for total mercury, divalent mercury, and methyl mercury. No estimates of aboveground plant concentration due to direct deposition will be made for carbon-14 and tritium (see Section 6.6.2). The aboveground plant concentrations due to direct deposition will be estimated for the following plant types: produce, forage, and silage.

The following equation calculates the aboveground plant concentration due to direct deposition for all COPCs except total mercury, divalent mercury, and methyl mercury, and for all ROPCs except carbon-14 and tritium:

$$Pd = \frac{CF \cdot Q \cdot (1 - F_v) \cdot [Dydp + (Fw \cdot Dywp)] \cdot Rp \cdot [1 - e^{(-kp \cdot Tp)}]}{Yp \cdot kp} \qquad \text{(Eq. 5-14 in HHRAP)}$$

The equation to calculate the aboveground plant concentration due to direct deposition for total mercury is:

$$Pd_{(Hg)} = \frac{0.48 \cdot CF \cdot Q \cdot (1 - F_v) \cdot [Dydp + (Fw \cdot Dywp)] \cdot Rp \cdot [1 - e^{(-kp \cdot Tp)}]}{Yp \cdot kp} \qquad \text{(Table B-2-7 in HHRAP)}$$

where:

Pd = concentration of COPC or ROPC in aboveground plant due to direct (wet and dry) deposition (mg COPC/kg plant tissue DW and pCi ROPC/g plant tissue DW).

$Pd_{(Hg)}$ = concentration of total mercury in aboveground plant due to direct (wet and dry) deposition (mg COPC/kg plant tissue DW).

CF = units conversion factor of 1000 (mg/g) for COPCs and 1×10^9 (pCi-kg/Ci-g) for ROPCs.

Q = COPC or ROPC-specific emission rate (g/s for COPCs and Ci/s for ROPCs), derived as described in Section 5.

F_v = fraction of COPC or ROPC air concentration in vapor phase (unitless). F_v is constituent-COPC-specific, ranges from 0 to 1, and is shown in Supplement 4. Constituents with a vapor fraction less than 0.05 are modeled as entirely particulate with an F_v value of 0 (CCN 097844). When F_v is not available, it is empirically derived for most constituents (except metals and some mercury compounds) using Eqs. A-2-1 and A-2-2 (when appropriate) in the HHRAP.

Dydp = unitized yearly average dry deposition from particle phase ($s/m^2 \cdot yr$). *Dydp*, from the air dispersion modeling, is stack-specific.

Fw = fraction of COPC or ROPC wet deposition that adheres to plant surfaces (unitless). A value of 0.2 is used for anions and two specific organic COPCs (p-chloroaniline and n-nitrosodi-n-propylamine) that ionize to anionic forms. A value of 0.6 is used for cations and all other organics (HHRAP Section 5.3.1). See Table 6-4.

Dywp = unitized yearly average wet deposition from particle phase ($s/m^2 \cdot yr$). *Dywp*, from the air dispersion modeling, is stack-specific.

Rp = interception fraction of the edible portion of plant for aboveground produce (unitless). *Rp* is plant-type-specific, with a value of 0.39 (representing a weighted average of fruits and vegetables [HHRAP Section 5.3.1.1]) used for produce, a value of 0.05 for forage, and a value of 0.46 (HHRAP Section 5.4.1.1) for silage. See Table 6-4.

e = base of the natural logarithm (unitless). $e = \sum_{i=0}^{\infty} \frac{1}{i!} \approx 2.718282$.

kp = plant surface loss coefficient (yr^{-1}). The recommended default value of 18 yr^{-1} (HHRAP Section 5.3.1.2) is used for all COPCs. For ROPCs, the effective *kp* includes a radioactive decay component (see Table 6-4).

Tp = length of plant exposure to deposition per harvest of edible portion of plant for aboveground produce (yr). The recommended default values of 0.164 yr for produce (HHRAP Section 5.3.1.3), 0.12 yr for forage, and 0.16 yr for silage (HHRAP Section 5.4.1.3) are used (Table 6-4).

Yp = yield or standing crop biomass of the edible portion of the plant for aboveground produce (productivity) (kg/m^2). *Yp* is site-specific and plant-type-specific. The recommended default value of 2.24 kg/m^2 (representing a weighted average of fruits and vegetables [HHRAP Section 5.3.1.4]) is used for produce, while a value of 0.15 kg/m^2 for forage (site-specific value, [Wisiol 1984]), and a value of 0.8 kg/m^2 (HHRAP Section 5.4.1.4) is used for silage. See Table 6-4.

0.48 = multiplier for modeling of total mercury (unitless), as shown in Table B-2-7 in the HHRAP.

The effective plant surface loss coefficient for ROPCs includes a component for wind removal, water removal, and growth dilution (14.06 day half-life), and a component for loss due to radioactive decay (isotope nuclear half-life). Equation 5-15 of the HHRAP is used to determine the effective plant surface loss coefficient; however, the radionuclide half-life plus 14.06 days is substituted for the term $t_{½}$ in Equation 5-15 of the HHRAP.

The following equation calculates the aboveground plant concentration due to direct deposition for divalent mercury:

$$Pd_{(Hg^{2+})} = 0.78 \cdot Pd_{(Hg)} \qquad \text{(Table B-2-7 in HHRAP)}$$

The equation to calculate the aboveground plant concentration due to direct deposition for methyl mercury is:

$$Pd_{(MHg)} = 0.22 \cdot Pd_{(Hg)} \qquad \text{(Table B-2-7 in HHRAP)}$$

where:

$Pd_{(Hg^{2+})}$	=	concentration of divalent mercury in aboveground produce due to direct (wet and dry) deposition (mg COPC/kg plant tissue DW)
$Pd_{(MHg)}$	=	concentration of methyl mercury in aboveground produce due to direct (wet and dry) deposition (mg COPC/kg plant tissue DW)
$Pd_{(Hg)}$	=	concentration of total mercury in aboveground produce due to direct (wet and dry) deposition (mg COPC/kg plant tissue DW). $Pd_{(Hg)}$ is calculated in Table B-2-7 in the HHRAP and shown above for produce, forage, and silage.
0.78	=	multiplier for modeling of divalent mercury (unitless), as shown in Table B-2-7 in the HHRAP
0.22	=	multiplier for modeling of methyl mercury (unitless), as shown in Table B-2-7 in the HHRAP

Note that in the equations to calculate the concentration in aboveground plants due to direct deposition, several parameters are stack-specific. This necessitates estimating the concentration in aboveground plants due to direct deposition for each stack individually. The individual concentrations from the three facility stacks will then be summed to obtain the overall concentration in aboveground plants due to direct deposition.

Also, note that in the equations to calculate the concentration in aboveground plants due to direct deposition, several parameters are plant-type-specific (produce, forage, and silage, for example). That is, when estimating the concentration in aboveground plants due to direct deposition for produce, the produce-specific parameters will be used. Likewise, when estimating the concentration in aboveground plants due to direct deposition for forage and silage, the forage-specific parameters and the silage-specific parameters will be used, respectively.

6.6.2 Aboveground Plants/Air-to-Plant Transfer

The equations used to estimate the aboveground plant concentration due to air-to-plant transfer are presented below. Per the HHRAP (EPA 2005), special consideration is given to modeling for total mercury, divalent mercury, and methyl mercury. Special consideration is also given to modeling for carbon-14 and tritium [see detailed discussion below, based on NRC guidance (NRC 1977)]. The aboveground plant concentrations due to air-to-plant transfer are estimated for the following plant types: produce, forage, and silage.

The following equation calculates the aboveground plant concentration due to air-to-plant transfer for all vapor-phase COPCs and ROPCs, except total mercury, divalent mercury, methyl mercury, carbon-14 and tritium:

$$Pv = \frac{Q \cdot F_v \cdot Cyv \cdot Bv_{ag} \cdot VG_{ag}}{\rho_a} \qquad \text{(Eq. 5-18 in HHRAP)}$$

The equation to calculate the aboveground plant concentration due to air-to-plant transfer for total mercury is:

$$Pv_{(Hg)} = \frac{0.48 \cdot Q \cdot F_v \cdot Cyv \cdot Bv_{ag} \cdot VG_{ag}}{\rho_a} \qquad \text{(Table B-2-8 in HHRAP)}$$

Where:

Pv = concentration of COPC or ROPC in aboveground plant due to air-to-plant transfer (mg COPC/kg plant tissue DW and pCi ROPC/g plant tissue DW). Note that a unit conversion factor of 1×10^9 (pCi/mCi) is used for ROPCs.

$Pv_{(Hg)}$ = concentration of total mercury in aboveground plant due to air-to-plant transfer (mg COPC/kg plant tissue DW).

Q = COPC- or ROPC-specific emission rate (g/s for COPCs and Ci/s for ROPCs), derived as described in Section 5.

F_v = fraction of COPC or ROPC air concentration in vapor phase (unitless). F_v is shown in Supplement 4. Constituents with a vapor fraction less than 0.05 are modeled as entirely particulate with an F_v value of 0 (CCN 097844). When F_v is not available, it is empirically derived for most constituents (except metals and some mercury compounds) using Eqs. A-2-1 and A-2-2 (when appropriate) in the HHRAP.

Cyv = unitized yearly average air concentration from vapor phase (µg-s/g-m^3 for COPCs and mCi-s/Ci-m^3 for ROPCs). Cyv, from the air dispersion modeling, is stack-specific.

Bv_{ag} = COPC or ROPC air-to-plant biotransfer factor for aboveground plant (unitless). Bv_{ag} is shown in Supplement 4. The Bv_{ag} value for produce is used to estimate aboveground plant concentration due to air-to-plant transfer for produce, while the Bv_{ag} value for forage (denoted as Bv_{forage} in Supplement 4) is used to estimate aboveground plant concentration due to air-to-plant transfer for both forage and silage (HHRAP Section A2-2.12.4). When Bv_{ag} values are not available, but sufficient information exists, guidance in HHRAP Section A2-2.12.4 was used where applicable for estimating Bv_{ag}. Note that because no values for Bv_{ag} could be found for radionuclides that are in vapor phase, Pv for air-to-plant transfer cannot be quantified for a few ROPCs.

VG_{ag} = empirical correction factor for the aboveground plant due to air-to-plant transfer (unitless). For produce, the recommended default values (HHRAP Section 5.3.2.1) for VG_{ag} are used: a value of 0.01 for COPCs and ROPCs with a $\log_{10}$ of the octanol/water partitioning coefficient (K_{ow}) ≥ 4 and a VG_{ag} value of 1 for COPCs and ROPCs with a log $K_{ow} < 4$. K_{ow} is COPC-specific. If no K_{ow} value exists for a constituent, the model conservatively uses $VG_{ag} = 1$. For forage and silage, the recommended default values of 1 and 0.5, respectively (HHRAP Section 5.4.2.1), are used for VG_{ag}. See Table 6-4.

ρ_a = density of air (g/m^3). The recommended default value of 1200 g/m^3 (EPA 2005) is used.

0.48 = multiplier for modeling of total mercury (unitless), as shown in EPA 2005.

The following equation calculates the aboveground plant concentration due to air-to-plant transfer for divalent mercury:

$$Pv_{(Hg^{2+})} = 0.78 \cdot Pv_{(Hg)} \qquad \text{(Table B-2-8 in HHRAP)}$$

The equation to calculate the aboveground plant concentration due to air-to-plant transfer for methyl mercury is:

$$Pv_{(MHg)} = 0.22 \cdot Pv_{(Hg)} \qquad \text{(Table B-2-8 in HHRAP)}$$

where:

$Pv_{(Hg^{2+})}$ = concentration of divalent mercury in aboveground plant due to air-to-plant transfer (mg COPC/kg plant tissue DW).

$Pv_{(MHg)}$ = concentration of methyl mercury in aboveground plant due to air-to-plant transfer (mg COPC/kg plant tissue DW).

$Pv_{(Hg)}$ = concentration of total mercury in aboveground plant due to air-to-plant transfer (mg COPC/kg plant tissue DW). $Pv_{(Hg)}$ is calculated in Table B-2-8 in the HHRAP.

0.78 = multiplier for modeling of divalent mercury (unitless), in Table B-2-8 of the HHRAP.

0.22 = multiplier for modeling of methyl mercury (unitless), as shown in Table B-2-8 of the HHRAP.

Note that in the equations to calculate the concentration in aboveground plants due to air-to-plant transfer, several parameters are stack-specific. This necessitates estimating the concentration in aboveground plants due to air-to-plant transfer for each facility stack individually. The individual concentrations from the three facility stacks then will be summed to obtain the overall concentration in aboveground plants due to air-to-plant transfer.

Also note that in the equations to calculate the concentration in aboveground plants due to air-to-plant transfer, several parameters are plant-type-specific (i.e., when estimating the concentration in aboveground plants due to air-to-plant transfer for produce, the produce-specific parameters are used). Likewise, when estimating the concentration in aboveground plants due to air-to-plant transfer for forage and silage, the forage-specific parameters and the silage-specific parameters are used, respectively.

As mentioned above, special consideration is given to modeling for carbon-14 and tritium. Risk calculations for most ROPCs are based on the assumption that radionuclides are present as particulates or vapors. However, special consideration must be given to carbon-14 and tritium, as these ROPCs are processed by vegetation with natural carbon and hydrogen, respectively. Thus, the vegetation ingestion pathway for carbon-14 and tritium is dependent on the exchange of carbon and hydrogen between plants and the environment. For this assessment, guidance from Regulatory Guide 1.109 (NRC 1977) is used to account for the bioaccumulation of carbon-14 and tritium in plants that could lead to human exposure

through vegetation ingestion. This is achieved through the use of correction factors and by using the assumptions that all carbon-14 is released by the WTP in oxide form (^{14}CO or $^{14}CO_2$) and tritium is released in water vapor. These correction factors will be applied to the concentration (e.g., pCi/L) estimated at the point of exposure by the air model.

The concentration of carbon-14 in vegetation is calculated assuming that its ratio to the natural carbon in vegetation is equal to the ratio of carbon-14 to natural carbon in the atmosphere surrounding the vegetation (NRC 1977):

$$C_{V(C-14)} = \frac{C_{A(C-14)} \cdot \mathrm{p} \cdot 0.11}{0.16} \qquad \text{(NRC 1977)}$$

where:

$C_{V(C\text{-}14)}$ = concentration of carbon-14 in vegetation (pCi ROPC/g plant tissue DW).

$C_{A(C\text{-}14)}$ = concentration of carbon-14 in the surrounding air (pCi/m^3). $C_{A(C\text{-}14)}$ is obtained from the air dispersion modeling.

p = ratio of the total annual release time to the total annual time during which photosynthesis occurs; a conservative ratio of 1.0 is used.

0.11 = fraction of the total plant mass that is natural carbon (dimensionless).

0.16 = concentration of natural carbon in the atmosphere (g/m^3).

The concentration of tritium in vegetation will be calculated based on the equilibrium between moisture in the air and water in plants (NRC 1977):

$$C_{V(H-3)} = C_{A(H-3)} \cdot 0.75 \cdot (0.5 \div Humidity) \qquad \text{(NRC 1977)}$$

where:

$C_{V(H\text{-}3)}$ = concentration of tritium in vegetation (pCi ROPC/g plant tissue DW).

$C_{A(H\text{-}3)}$ = concentration of tritium in the surrounding air (pCi/m^3). $C_{A(H\text{-}3)}$ is obtained from the air dispersion modeling.

0.75 = fraction of the total plant mass that is water (dimensionless).

0.5 = ratio of tritium concentration in plant water to tritium concentration in atmospheric water (dimensionless).

Humidity = absolute humidity of the atmosphere (g/m^3). A site-specific relative humidity value of 55.1 %, (the equivalent of 6.0 g/m^3 absolute humidity) is used. The value was determined from the average of relative humidity measurements taken from the Hanford Meteorological Station for years 2002 through 2006 (conversion from relative to absolute humidity was done using the average temperature and atmospheric pressure taken from the Hanford Meteorological Station for years 2002 through 2006 [12.5 °C and 0.98 atm]).

The concentration of carbon-14 and tritium in vegetation will be used as the total plant concentration for these ROPCs throughout the risk assessment, instead of estimating concentrations for specific types of

plants (e.g., produce, forage, silage, and grain) and specific parts of the plants (i.e., aboveground and belowground).

6.6.3 Root Uptake

The concentration of COPCs and ROPCs in plants due to root uptake from the soil will be calculated for aboveground and belowground plants. These concentrations are calculated for all COPCs and all ROPCs except carbon-14 and tritium (see Section 6.6.2). The concentration in plants due to root uptake from the soil is a function of the soil concentration and a soil-to-plant bioaccumulation uptake factor. Section 6.6.3.1 discusses the modeling of aboveground plants due to root uptake. Section 6.6.3.2 discusses the modeling of belowground plants due to root uptake. A discussion of uptake factors is presented in Section 6.6.3.3.

6.6.3.1 Root Uptake/Aboveground Plants

The concentration in aboveground plants due to root uptake is a function of the soil concentration and the soil-to-plant bioaccumulation uptake factor for aboveground plants. The aboveground plant concentrations due to root uptake will be estimated for the following plant types: produce, forage, silage, and grain. No estimates of aboveground plant concentration due to root uptake will be made for carbon-14 and tritium, because a "vegetation concentration" will be estimated as the total plant concentration for these two isotopes (see Section 6.6.2). Also, the untilled soil depth of 2 cm is considered too shallow to estimate plant concentrations for consumption by human and ecological receptors; thus, only root zone soil concentrations (depth of 15 cm for wild produce, forage, wild grain/seed) and tilled soil concentrations (depth of 20 cm for domestic produce, silage, domestic grain) are used to model aboveground plants due to root uptake.

The following equation calculates the aboveground plant concentration due to root uptake for all COPCs and for all ROPCs, except carbon-14 and tritium:

$$Pr_{ag} = Cs \cdot Br_{ag} \qquad \text{(Eq. 5-20A in HHRAP)}$$

where:

Pr_{ag} = concentration of COPC or ROPC in aboveground plant due to root uptake (mg COPC/kg plant tissue DW and pCi ROPC/g plant tissue DW). Pr_{ag} is calculated separately for domestic vegetation (tilled soil – 20 cm depth) and wild vegetation (root-zone soil – 15 cm depth). See the discussion below for appropriate combinations of plant types (i.e., produce, forage, silage, and grain) and soil depths.

Cs = soil concentration (mg/kg for COPCs and pCi/g for ROPCs). Cs is depth-specific and calculated in accordance with Section 6.2 (HHRAP equations 5-1B though 5-1E, as modified for exposure timing and duration).

Br_{ag} = plant-soil bioconcentration factor for aboveground produce (unitless). Br_{ag} is shown in Supplement 4. Separate Br_{ag} values are used for produce (denoted as Br_{ag}), forage and silage (per EPA 2005, Br_{forage} is used to denote and estimate both forage and silage), and grain (denoted as Br_{grain}). The values for Br_{ag} in Supplement 4 (organic COPCs), will be compared against the calculated mass-limited uptake factors that are described in Section 6.6.3.3 (values shown in Appendix A), and the smaller of the two values will be used in the calculation of the aboveground plant concentration due to root uptake

(Pr_{ag}). The use of the smaller value in this comparison prevents the overestimation of Pr_{ag}, because, in some cases, the derived uptake factors (Br_{ag}) are not physically possible, leading to the prediction of more chemical being accumulated by an organism from the soil than is released from the facility and deposited onto the soil. In this situation, use of the mass-limited uptake factor prevents the overestimation of Pr_{ag}.

Note that in the equations above, four different plant types (produce, forage, silage, and grain) are modeled. When estimating the concentration in aboveground plants due to root uptake for produce, the produce-specific parameters are used. Likewise, when estimating the concentration in aboveground plants due to root uptake for forage, silage, and grain, the forage-specific parameters, silage-specific parameters, and grain-specific parameters will be used, respectively.

Note also that in the equations above, two different soil depths (tilled soil and root-zone soil) are used because untilled soil (2 cm depth) is considered too shallow for plants with root uptake. However, not every combination of the two soil types with the four plant types is appropriate. The following combinations of soil types and plant types will be used in estimating the aboveground plant concentration due to root uptake:

- When estimating concentrations for aboveground plants due to root uptake for domestic produce, the tilled soil concentrations will be used.
- When estimating concentrations for aboveground plants due to root uptake for wild produce, the root-zone soil concentrations will be used.
- When estimating concentrations for aboveground plants due to root uptake for forage, the root-zone soil concentrations will be used.
- When estimating concentrations for aboveground plants due to root uptake for silage, the tilled soil concentrations will be used.
- When estimating concentrations for aboveground plants due to root uptake for grain, both the tilled soil concentrations and root-zone soil concentrations will be used. Grain modeled from tilled soil will be used in subsequent modeling of domesticated animals (e.g., animals on a farm, such as chickens), while grain modeled from root-zone soil will be used in subsequent modeling of wild animals (e.g., game animals such as wild fowl).

6.6.3.2 Root Uptake/Belowground Plants

The concentration in belowground plants due to root uptake is a function of the soil concentration, the soil-to-plant bioaccumulation uptake factor for belowground plants, and a correction factor for belowground produce. The belowground plant concentrations due to root uptake will be estimated for only one plant type: produce. No estimates of belowground plant concentration due to root uptake will be made for carbon-14 and tritium, because a "vegetation concentration" will be estimated as the total plant concentration for these two isotopes (see Section 6.6.2). Also, the untilled soil depth of 2 cm is considered too shallow to estimate plant concentrations for consumption by human and ecological receptors; thus, only root zone soil concentrations (depth of 15 cm for wild produce) and tilled soil concentrations (depth of 20 cm for domestic produce) will be used to model belowground plants due to root uptake.

The following equation calculates the belowground plant concentration due to root uptake for all COPCs and for all ROPCs, except carbon-14 and tritium:

$$Pr_{bg} = Cs \cdot Br_{rootveg} \cdot VG_{rootveg} \qquad \text{(Eq. 5-20B in HHRAP)}$$

where:

Pr_{bg} = concentration of COPC or ROPC in belowground plant due to root uptake (mg COPC/kg plant tissue DW and pCi ROPC/g plant tissue DW). Pr_{bg} is calculated separately for domestic vegetation (tilled soil - 20 cm depth) and wild vegetation (root-zone soil - 15 cm depth).

Cs = soil concentration (mg/kg for COPCs and pCi/g for ROPCs). Cs is depth-specific and calculated in accordance with Section 6.2 (HHRAP equations 5-1B though 5-1E, as modified for exposure timing and duration).

$Br_{rootveg}$ = plant-soil bioconcentration factor for belowground plants (unitless). Note that per the HHRAP equation 5-20B, for organic COPCs, $Br_{rootveg}$ can be calculated as $RCF \div (Kd_s \times CF)$, where RCF is the root concentration factor (mL/g), Kd_s is the soil-water partition coefficient (L/kg), and CF is a units-conversion factor of 1 (kg·mL)/(g·L). Values for RCF, Kd_s, and $Br_{rootveg}$ are shown in Supplement 4. The values for $Br_{rootveg}$ in Supplement 4 (organic COPCs) will be compared against the calculated mass-limited uptake factors for produce that are described in Section 6.6.3.3 (values in Appendix A), and the smaller of the two values will be used in the calculation of the belowground plant concentration due to root uptake (Pr_{bg}). The use of the smaller value in this comparison prevents the overestimation of Pr_{bg}, because in some cases, the derived uptake factors ($Br_{rootveg}$) are not physically possible, leading to the prediction of more chemical being accumulated by an organism from the soil than is released from the facility and deposited onto the soil. In this situation, use of the mass-limited uptake factor prevents the overestimation of Pr_{bg}.

$VG_{rootveg}$ = empirical correction factor for belowground plants (unitless). For belowground plants, the recommended default values (HHRAP Section 5.3.3) for $VG_{rootveg}$ are used: a value of 0.01 for COPCs and ROPCs with a $\log_{10} K_{ow} \geq 4$ and a $VG_{rootveg}$ value of 1 for COPCs and ROPCs with a $\log_{10} K_{ow} < 4$ (see Table 6-4). If no K_{ow} value exists for a constituent, the model conservatively uses $VG_{rootveg} = 1$. K_{ow} is constituent-specific and shown in Supplement 4.

Note that in the equation above, two different soil depths (tilled soil and root-zone soil) will be used because untilled soil (2 cm depth) is considered too shallow for plants with root uptake. Domestic root vegetables grown in tilled soil (20 cm depth) will be used in subsequent human health risk equations for the resident consuming produce, while wild root vegetables grown in root-zone soil (15 cm depth) will be used in subsequent human health risk equations for American Indian scenarios where wild produce is gathered and consumed (see Section 7.1.3 for a description of the receptors and exposure pathways).

6.6.3.3 Mass-Limited Soil-to-Plant Uptake Factors

The concentrations of contaminants in plants due to root uptake, for both aboveground and belowground plants, are a function of the soil concentration and soil-to-plant bioaccumulation uptake factor. Soil

concentrations used in the modeling of aboveground and belowground plants due to root uptake will be from the root-zone depth (15 cm, wild vegetation) and from the tilled soil depth (20 cm, domestic vegetation); the untilled soil depth (2 cm) is considered too shallow for the modeling of aboveground and belowground plants due to root uptake. The uptake factors for organic chemicals recommended in the HHRAP and SLERAP are calculated from regression equations developed for a few chemicals and exposure situations. In some cases these derived uptake factors are not physically possible because they predict that an organism will accumulate more chemical from the soil than is released from the facility and deposited onto the soil. This problem affects a subset of the organic chemicals being evaluated for the WTP.

For example, if 1 mg of methyl alcohol is deposited per square meter of soil at the point of maximum deposition (calculated as [total deposition rate]×[total years of deposition]×[units conversion factor]), then applying the root-to-aboveground produce transfer factor (Br_{ag}) recommended by EPA companion database (EPA 2005) would give a resulting accumulation of 8.38 mg of methyl alcohol in the aboveground edible tissues of plants in one growing season in a 1 square meter area (calculated as [concentration in soil]×[EPA uptake factor]×[EPA default value for yield for produce]). This is more than 8 times the amount of chemical available from 40 years of WTP emissions. This overestimate would then be carried through the risk assessment. For example, if the aboveground plant concentration were overestimated by a factor of more than 8, then risk to human and ecological receptors from ingestion of aboveground plant tissue would also be overestimated by a factor of more than 8. This uptake factor problem does not apply to all COPCs but is limited to some organic chemicals. Uptake factors for organic chemicals are calculated using regression equations; uptake factors for inorganic chemicals and radionuclides are taken from more empirical sources, are sufficiently known, and are not included in this discussion.

There are a variety of ways that this problem may be corrected, depending on the source of the original uptake factor and the amount of uptake information available. Possible solutions include:

- Identify published, empirically-derived uptake factors for the organic chemicals, including development of more representative equations for estimating uptake factors for organic chemicals.
- Conduct laboratory experiments to measure realistic, site-specific, uptake factors.
- Calculate "mass-limited" uptake factors that assume all of the chemical deposited onto the soil is taken up by an organism.

For this risk assessment, the calculation of "mass-limited" uptake factors has been determined to be the most reasonable option and will been performed. Maximum (mass-limited) uptake factors based on simple conservation of mass (that is, that result in transfer of 100 % of the deposited chemical into the receiving organism, but no more) can be calculated. These calculations can be shown to be a function of the soil density and the plant yield. Since the soil density is dependent on the soil depth, and since the root-zone and untilled soil depths apply to the plant concentration due to root uptake, separate determinations of the soil-to-plant, mass-limited uptake factor must be made for these two depths.

The initial soil-to-plant, mass-limited uptake factor (i.e., before adjustments are made for the length of operation for the facility and to divide aboveground and belowground produce) is calculated as:

$$\text{Initial Uptake Factor} = \text{Soil Density} \div \text{Plant Yield}$$

where:

Initial Uptake Factor	=	initial calculation of soil-to-plant uptake factor (kg soil/m^2 per kg DW plant/m^2).
Soil Density	=	soil density (kg soil/m^2), calculated as bulk density (in kg soil/m^3) times soil depth (in meters) (that is, mass per area for a specific depth). For example, using a soil bulk density of 1.3 g/cm^3 (1300 kg/m^3) and a soil depth of 15 cm (0.15 m), the soil density is (1300 kg/m^3) (0.15 m) = 195 kg/m^2. The soil density for tilled soil (that is, at the 20 cm depth) is (1300 kg/m^3) (0.2 m) = 260 kg/m^2. Both soil depths are used to estimate separate mass-limited uptake factors.
Plant Yield	=	yield for the plant (kg DW plant/m^2). Plant yields used are 2.24 kg/m^2 for aboveground produce (EPA 2005), 0.25 kg/m^2 for belowground produce (USDA 2009; Baes et. al. 1984), 0.15 kg/m^2 for forage (Wisiol 1984), 0.8 kg/m^2 for silage (EPA 2005), and 0.25 kg/m^2 for grain (Baes et al. 1984, Figure 4.14); see Table 6-4.

As seen above, the initial soil-to-plant, mass-limited uptake factor is a function of the soil density (which is dependent on the depth of soil) and the plant yield. These mass-limited uptake factors assume that:

- In one growing season, the plant takes up all of the chemical deposited over 40 years.
- The plant concentrates all of the deposited chemical into the aboveground edible portion of the plant.

These assumptions directly contradict other assumptions recommended in the risk assessment guidance (EPA 2005):

- If the plant takes up the entire deposited chemical in one growing season, a human receptor cannot be exposed to this concentration for the recommended exposure durations (which are longer than one year for the various adult receptors).
- If plants take up all of the deposited chemical in the aboveground portion, the concentration in the belowground portion (i.e., root vegetables) must be zero.

To prevent this contradiction, reasonable maximum uptake factors can be calculated using the following assumptions:

- The plants take up one year's worth of deposition each growing season so that for each year of exposure, the plants take up all the deposition available that year.
- The plants take up one-half of the available chemical into the edible aboveground portion and one-half into the edible belowground portion.

Using these assumptions, reasonable maximum uptake factors can be calculated as:

Mass-limited Uptake Factor = Initial Uptake Factor × Modifying Factor

where:

Mass-limited Uptake Factor	=	final mass-limited, soil-to-plant uptake factor (kg soil/m^2 per kg DW plant/m^2)
Initial Uptake Factor	=	initial estimate of uptake factor (Soil Density ÷ Plant Yield)
Modifying Factor	=	adjustments necessary for aboveground versus belowground portions of the plant and for operating duration of the facility that is producing emissions

There are two types of modifying factors used to estimate the mass-limited uptake factor; these modifying factors are dependent on the type of plant (e.g., produce, forage, silage, and grain). One type of modifying factor is applied to plant types that have both aboveground and belowground concentrations. For produce, a modifying factor of 1/2 is applied to aboveground produce due to root uptake, and a modifying factor of 1/2 is applied to belowground produce due to root uptake (so as to equally divide the mass-limited uptake factor between aboveground and belowground produce due to root uptake). However, this modifying factor related to aboveground as compared to belowground is not applied to forage, silage, or grain, since the edible portions of these plant types are all totally aboveground. The second type of modifying factor (a modifying factor of 1/40) is used to apportion the depositions over the 40-year duration of the facility. This second type of modifying factor is applied to produce, silage, and grain because these products will be harvested and the chemicals in them removed from the soil. This 40-year modifying factor is not applied to forage because some of the forage will remain and decay in place, thus returning the chemicals to the soil. Therefore, the modifying factors (combining the two types of modifying factors, as appropriate) are:

- 1/80 for aboveground produce due to root uptake (1/2 × 1/40)
- 1/80 for belowground produce due to root uptake (1/2 × 1/40)
- 1 for forage (no modifying factor applied)
- 1/40 for silage (1/2 modifying factor not applied)
- 1/40 for grain (1/2 modifying factor not applied)

All of the modifying factors will be used for human health exposure pathways. In contrast, ecological receptors are assumed to consume only forage, so a modifying factor is not used for ecological receptors.

Soil-to-plant, mass-limited uptake factors are calculated in Appendix A. The final step in this mass-limited uptake factor approach is to compare the uptake factors as calculated per the HHRAP guidance (EPA 2005) to these calculated mass-limited uptake factors, on a chemical-by-chemical basis for organic COPCs. The smaller of the two values will be used in the estimation of plant concentrations.

6.7 Other Media

Modeling for various animal products (such as wild game and fish) is also necessary for this risk assessment. However, since this modeling effort is slightly different for the human health risk assessment (HHRA), as opposed to the ERA, the modeling will be described in Section 7.1.7.5 for human health receptors and in Section 8.2.3.1 for ecological receptors.

6.8 Uncertainty in Fate and Transport Modeling

Uncertainties will be presented in the risk assessment for each aspect of the environmental fate and transport modeling. This includes air dispersion modeling, soil accumulation modeling, surface water modeling, sediment modeling, and plant accumulation modeling. The uncertainty assessment will be presented in the form of both text and tables summarizing the primary contributors and potential magnitude of uncertainties.

A variety of conservative assumptions are used throughout the modeling process to compensate for uncertainties. Some important sources of uncertainty in each type of modeling are summarized in the following sections.

6.8.1 Uncertainty in Air Dispersion Modeling

A number of sources of uncertainty exist in the air dispersion modeling, such as:

- Input values, such as stack emission characteristics
- Emission rates of individual COPCs and ROPCs
- Upset factor multipliers used to bound emissions of COPCs and ROPCs
- Meteorological data
- Accurate simulation of the atmospheric dispersion of emissions plume from each stack

Some of these uncertainties are based on the limited data available, such as estimated emission rates as described in Section 5.5. Other uncertainties become larger when the model is used at the limits of its normal application (for instance, in very complex terrain as distances from the source increase).

6.8.2 Uncertainty in Soil Accumulation Modeling

Estimating soil concentrations incorporates numerous uncertainties, which are inherent in the assumptions that are the basis for the calculations. Examples of uncertainty in the parameters would be soil mixing depth, soil bulk density, and volumetric water content, which are assigned a single value, but may vary widely over a relatively small area. The concentration of COPCs and ROPCs in soil will be subject to loss due to biotic and abiotic degradation; however, transformation and subsequent increase of secondary COPCs (that is, degradation products) will not be considered in the assessment. Transformation of ROPCs and formation of daughter products will be included in this assessment through the use of toxicity values (slope factors) that include daughter products.

6.8.3 Uncertainty in Surface Water Accumulation Modeling

Uncertainty in the estimation of surface water and fish concentrations of COPCs and ROPCs results from the assumptions used in the calculations. The equations assume that the water body reaches a steady-state condition; however, for application to the Columbia River and any other flowing surface water, this assumption is extremely conservative. Additionally, many of the equations used to model the fate of COPCs and ROPCs deposited into the water body greatly simplify the mechanisms occurring within such a dynamic system and may overestimate or underestimate the concentration of given COPCs and ROPCs in the surface water. It is also assumed that the maximum deposition of COPCs and ROPCs occurs over

the entire depositional area of the water body, which is a source of additional uncertainty and conservatism.

6.8.4 Uncertainty in Sediment Accumulation Modeling

There is uncertainty in assigning COPCs exclusively to either water column or bed sediment for purposes of estimating fish-tissue concentrations as described in the HHRAP and concentrations of other organisms as described in the SLERAP. The problem is that this approach to partitioning COPCs in the aquatic environment may not reflect the multiple pathways by which different kinds of organisms are potentially exposed to any given contaminant.

The EPA approach estimates concentrations of organisms using bioconcentration factors (*BCF*s) and dissolved water concentrations for COPCs with low values for K_{ow}, bioaccumulation factors (*BAF*s) and whole-water concentrations for COPCs with moderate values for K_{ow}, and *BAF*s and sediment concentrations for COPCs with high values for K_{ow}. The uncertainty lies in the source and meaning of the different biotransfer factors used for the different media. If the EPA (2005) biotransfer factors do not incorporate all the pathways to all organisms from the single medium where each COPC is assumed to predominate, then the exposure will be underestimated. It is unlikely that the EPA transfer factors account for all pathways relevant to all fish.

Fish take up contaminants into their tissue via the water in contact with their gills and via the ingestion of water, abiotic particulates, and biota. Some organisms will be primarily exposed by one pathway, while others will be exposed over multiple pathways:

- Dissolved contaminants are primarily taken up across the gill membrane; thus, all organisms living in the water column will be exposed to dissolved contaminants.
- Filter-feeding organisms, which usually live in the water column, will also be exposed to contaminants bound to suspended particulates that they filter out of the water and ingest.
- Sediment-ingesting organisms that live in the water column will also be exposed to sediment contaminants by direct ingestion.
- Predatory fish, which are also water-column dwellers, will also be exposed to dissolved, particulate-bound, and sediment contaminants by ingesting prey that were so exposed, as well as by direct uptake from the water column and ingestion of suspended particulates.

In fact, there are probably few organisms that are exposed to only dissolved contaminants, perhaps only those that live in the water column and selectively feed on planktonic animals to the exclusion of abiotic particulates. Therefore, assigning each contaminant to a particular class of media (dissolved water, whole water, and bed sediment) based on its tendency to adsorb to particles or organic carbon, potentially neglects pathways from other media. Further discussion of uncertainty related to these pathways is presented in the ecological section (Section 8.6) of this work plan.

6.8.5 Uncertainty in Plant Accumulation Modeling

Calculation of COPC and ROPC concentrations in biota incorporates the uncertainties inherent in calculation of air and soil concentrations because the air and soil are the sources of COPCs and ROPCs to plants. Uncertainties also arise from the assumption that the location of maximum soil concentration is the location of exposure to biota over a multiple-year period. Additionally, although COPCs and ROPCs are incorporated into plants and animal tissue, it is assumed that the COPC and ROPC concentration in

soil does not decrease due to these processes. Assumptions of the animal feed ingestion rates introduce additional uncertainty because they are based on average rates.

Additional pathways, such as fugitive dust emissions or entrainment of soil in rainwater splash, may contribute to COPC and ROPC concentrations in biota. However, no equations are available to quantify these pathways. In addition, the chemical transport through inedible portions of plants (such as corn husks) may contribute to COPC and ROPC concentrations in edible portions of plants (such as corn kernel). Transfer factors for this type of chemical transport are not available.

6.9 Summary of Environmental Modeling

Air dispersion modeling will be used to determine COPC- and ROPC-specific concentrations and deposition rates resulting from emissions of the WTP. The assessment area extends to a 50-km radius from the WTP. These results will be used as input into the human health and ecological risk assessments.

The CALPUFF model will be used for the air-quality modeling task. The WTP emissions, as determined by the design engineers, and 5 years of upper air and Hanford Site meteorological data collected by the Hanford Site Meteorological Station network will be used as input into the model. The COPC and ROPC-specific concentrations and deposition rates will be calculated at a gridded network of receptors and at specific sensitive receptors identified by the risk assessment analysts.

Fate and transport modeling will be used to estimate COPC and ROPC concentrations in various exposure media (air, soil, surface water, sediment, plants, and animal tissue). This modeling effort will utilize assumed emissions rates with a combination of site-specific and default parameters to describe the movement of COPCs and ROPCs through the environment. This modeling is predictive and cannot be confirmed by sampling environmental media since the emissions source does not yet exist. The uncertainty associated with this predictive modeling is addressed through the use of conservative assumptions whenever possible. Estimated media concentrations resulting from this modeling effort will be used in the exposure assessment for the human health (Section 7) and ecological (Section 8) risk assessments. Environmental modeling will be the same for the PRA and final risk assessment (FRA) with the possible inclusion of additional site-specific modeling parameters in the FRA.

6.10 References

6.10.1 Project Documents

CCN 097844, *Discuss and Resolve the Outstanding Risk Assessment Issues in the Risk Assessment Work Plan (RAWP),* Meeting minutes from a meeting held on 9 September 2004 between WTP, US Environmental Protection Agency, Region 10, and Washington Department of Ecology, in Seattle, Washington, USA.

CCN 194345, meeting minutes, D. Blumenkranz (WTP) to C. Bowman (Ecology) and others, *Modeling Particle-bound Constituents in CalPuff*, 25 June 2009.

24590-CM-HC4-HKYM-00001-01-00002, Rev 00A, *Modeling Verification and Methods Report, River Protection Project, Hanford Tank Waste Treatment and Immobilization Plant.*

24590-WTP-HPC-M30T-00002, Rev 00B, *WTP Stack Parameters and Flow.*

24590-WTP-RPT-ENV-08-001, Rev 1, *Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol.*

24590-WTP-RPT-ENV-13-001, Rev 0, *CALPOST Data Evaluation to Support the Environmental Risk Assessment.*

6.10.2 Codes and Standards

40 CFR 51. App. W. "Guideline on Air Quality Models", US Environmental Protection Agency, *Code of Federal Regulations*, as amended.

6.10.3 Other Documents

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PNNL. 2006. *Hanford Site Environmental Report for Calendar Year 2005*, PNNL-15892, September 2006. Pacific Northwest National Laboratory, Richland, Washington.

NRC. 1977. *Calculation of Annual Doses to man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I*, Regulatory Guide 1.109, October 1977. Office of Standard Development, US Nuclear Regulatory Commission, Washington, DC.

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Table 6-1 CALMET Model Input Assumptions

Level	1	2	3	4	5	6	7	8	9
Cell face heights (m)	20	40	80	160	320	670	1400	2600	4000
BIAS	0	0	0	0	0	0	0	0	0

Other CALMET parameters	IEXTRP	R1	R2	RMAX1	RMAX2
	4	10	12	12	12

Scavenging Coefficient For Wet Deposition			
Species	Species Abbreviation	Liquid Precipitation	Frozen Precipitation
Pretreatment Facility Vapor Concentration	PTFV	0.00017	0.00006
Pretreatment Facility Particulate Concentration (1 micron)	PTFP1	0.00005	0.000017
Pretreatment Facility Particulate Concentration (2.5 micron)	PTFP25	0.00005	0.000017
LAW Facility Vapor Concentration	LAWV	0.00017	0.00006
LAW Facility Particulate Concentration (1 micron)	LAWP1	0.00005	0.000017
LAW Facility Particulate Concentration (2.5 micron)	LAWP25	0.00005	0.000017
HLW Facility Vapor Concentration	HLWV	0.00017	0.00006
HLW Facility Particulate Concentration (1 micron)	HLWP1	0.00005	0.000017
HLW Facility Particulate Concentration (2.5 micron)	HLWP25	0.00005	0.000017

Reference: 24590-WTP-RPT-ENV-08-001, Rev 1, *Hanford Tank Waste Treatment and Immobilization Plant Risk Assessment Air Quality Modeling Protocol,* Supplement 5

Table 6-2 Site-Specific Parameters Used in Modeling Soil Concentrations

Parameter	Value	Units	Source or Reference
Total watershed area receiving deposition (A_L)	3.927×10^9	m^2	Value estimated as half of the study area
Soil bulk density (BD)	1.3	g/cm^3	Halvorson JJ, McCool DK, King LG, and Gatto LW. 1998. *Ground Freezing Effects on Soil Erosion of Army Training Lands. Part 2. Overwinter Changes to Tracked-Vehicle Ruts*, Yakima Training Center, Washington, Special Report 98-8. Cold Regions Research and Engineering Laboratory, US Army Corps of Engineers.
USLE cover management factor (C)	0.1	unitless	Table B-4-13 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities,* EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm (dense vegetative cover assumed).
Soil enrichment ratio (ER)	Inorganics: 1 Organics: 3	unitless	Table B-1-3 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Average annual evapotranspiration (E_v)	16.8	cm/yr	Wisiol K. 1984. "Estimating Grazingland Yield from Commonly Available Data," in J. Range Mgmt., Volume 37, Issue 5, p 471-475, September 1984.
Average annual irrigation (I)	0	cm/yr	assumed value
USLE erodibility factor (K)	0.39	ton/acre	Table B-4-13 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
USLE length-slope factor (LS)	1.5	unitless	Table B-4-13 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.

Table 6-2 Site-Specific Parameters Used in Modeling Soil Concentrations

Parameter	Value	Units	Source or Reference
Average annual precipitation (*P*)	18.47	cm/yr	Average annual precipitation computed from Hanford Environmental Reports, years 2002 through 2006; PNNL. 2003. *Hanford Site Environmental Report for Calendar Year 2002*. PNNL-14295, Pacific Northwest National Laboratory, Richland, Washington, September 2003. PNNL. 2004. *Hanford Site Environmental Report for Calendar Year 2003*. PNNL-14687, Pacific Northwest National Laboratory, Richland, Washington, September 2004. PNNL. 2005. *Hanford Site Environmental Report for Calendar Year 2004*. PNNL-15222, Pacific Northwest National Laboratory, Richland, Washington, September 2005. PNNL. 2006. *Hanford Site Environmental Report for Calendar Year 2005*. PNNL-15982, Pacific Northwest National Laboratory, Richland, Washington, September 2006. PNNL. 2007. *Hanford Site Environmental Report for Calendar Year 2006*. PNNL-16623, Pacific Northwest National Laboratory, Richland, Washington, September 2007.
USLE supporting practice factor (*PF*)	1	unitless	Table B-4-13 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Ideal Gas Law Constant (*R*)	0.08205746	L·atm/ mol·°K	Wikimedia Foundation, Inc., St. Petersburg, Florida (http://en.wikipedia.org/wiki/Universal_gas_constant, accessed July 2006)
USLE rainfall (or erosivity) factor (*RF*)	20	yr^{-1}	Site-specific value from Figure 1 of Wischmeier and Smith 1978.
Average annual surface runoff from pervious areas (*RO*)	2.5	cm/yr	Estimated: assumes the majority of rainfall recharges or evaporates

Table 6-2 Site-Specific Parameters Used in Modeling Soil Concentrations

Parameter	Value	Units	Source or Reference
Ambient temperature (T_a)	286	°K	Average ambient air temperature computed from Hanford Environmental Reports, years 2002 through 2006; PNNL. 2003. *Hanford Site Environmental Report for Calendar Year 2002*. PNNL-14295, Pacific Northwest National Laboratory, Richland, Washington, September 2003. PNNL. 2004. *Hanford Site Environmental Report for Calendar Year 2003*. PNNL-14687, Pacific Northwest National Laboratory, Richland, Washington, September 2004. PNNL. 2005. *Hanford Site Environmental Report for Calendar Year 2004*. PNNL-15222, Pacific Northwest National Laboratory, Richland, Washington, September 2005. PNNL. 2006. *Hanford Site Environmental Report for Calendar Year 2005*. PNNL-15982, Pacific Northwest National Laboratory, Richland, Washington, September 2006. PNNL. 2007. *Hanford Site Environmental Report for Calendar Year 2006*. PNNL-16623, Pacific Northwest National Laboratory, Richland, Washington, September 2007.
Water body temperature (T_{wk})	285	°K	Average median Columbia River temperature (Vernita Bridge measurement) computed from Hanford Environmental Reports, years 2002 through 2006; PNNL. 2003. *Hanford Site Environmental Report for Calendar Year 2002*. PNNL-14295, Pacific Northwest National Laboratory, Richland, Washington, September 2003. PNNL. 2004. *Hanford Site Environmental Report for Calendar Year 2003*. PNNL-14687, Pacific Northwest National Laboratory, Richland, Washington, September 2004. PNNL. 2005. *Hanford Site Environmental Report for Calendar Year 2004*. PNNL-15222, Pacific Northwest National Laboratory, Richland, Washington, September 2005. PNNL. 2006. *Hanford Site Environmental Report for Calendar Year 2005*. PNNL-15982, Pacific Northwest National Laboratory, Richland, Washington, September 2006. PNNL. 2007. *Hanford Site Environmental Report for Calendar Year 2006*. PNNL-16623, Pacific Northwest National Laboratory, Richland, Washington, September 2007.
Empirical intercept coefficient (a)	0.6	unitless	Table B-4-14 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.

Table 6-2 Site-Specific Parameters Used in Modeling Soil Concentrations

Parameter	Value	Units	Source or Reference
Empirical slope coefficient (b)	0.125	unitless	Table B-4-14 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Fraction of organic carbon in soil ($f_{oc,s}$)	0.0044	unitless	Average TOC. CCN 150854, E-mail from Jerry Yokel, Washington Department of Ecology, to David Blumenkranz, WTP, *Ecology Sample Results (soil TOC and pH)*, January 02, 2007, Richland, Washington.
Soil volumetric water content (θ_{sw})	0.2	mL/cm^3	Table B-1-3 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Solids particle density (ρ_{soil})	2.7	g/cm^3	Table B-1-6 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.

Table 6-3 Site-Specific Parameters Used in Modeling Surface Water and Sediment

Parameter	Value	Units	Source or Reference
Area of impervious watershed receiving deposition (A_I)	0	m^2	Estimated: assumes deposited COPCs are all mixed with soil
Total watershed area receiving deposition (A_L)	3.927×10^9	m^2	Value estimated as half of the study area
Water body surface area (A_w)	3.652×10^7	m^2	PNNL. 2005. *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415, Rev 17, September 2005, Pacific Northwest National Laboratory, Richland, Washington. (Sect. 4, pg 41, footnote a)
Soil bulk density (BD)	1.3	g/cm^3	Halvorson JJ, McCool DK, King LG, and Gatto LW. 1998. *Ground Freezing Effects on Soil Erosion of Army Training Lands. Part 2. Overwinter Changes to Tracked-Vehicle Ruts*, Yakima Training Center, Washington, Special Report 98-8. Cold Regions Research and Engineering Laboratory, US Army Corps of Engineers.
USLE cover management factor (C)	0.1	unitless	Table B-4-13 of EPA, 2005, Human Health Risk Assessment *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm. (dense vegetative cover assumed)
Bed sediment concentration (C_{BS})	1	g/cm^3	Table B-4-22 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
USLE erodibility factor (K)	0.39	ton/acre	Table B-4-13 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Gas-Phase Transfer Coeff. (K_G)	36500	m/yr	Calculated value per Table B-4-21 in EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
USLE length-slope factor (LS)	1.5	unitless	Table B-4-13 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.

Table 6-3 Site-Specific Parameters Used in Modeling Surface Water and Sediment

Parameter	Value	Units	Source or Reference
USLE supporting practice factor (*PF*)	1	unitless	Table B-4-13 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Ideal Gas Law Constant (*R*)	0.08205746	L-atm/ mol-°K	Wikimedia Foundation, Inc., St. Petersburg, Florida (http://en.wikipedia.org/wiki/Universal_gas_constant, accessed July 2006)
USLE rainfall (or erosivity) factor (*RF*)	20	1/yr	Site-specific value from Figure 1 of Wischmeier and Smith 1978.
Average annual surface runoff from pervious areas (*RO*)	2.5	cm/yr	Estimated: assumes the majority of rainfall recharges or evaporates
Total suspended solids concentration (*TSS*)	10	mg/L	Table B-4-16 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Water body temperature (T_{wk})	285	°K	Average median Columbia River temperature (Vernita Bridge measurement) computed from Hanford Environmental Reports, years 2002 through 2006; PNNL. 2003. *Hanford Site Environmental Report for Calendar Year 2002*. PNNL-14295, Pacific Northwest National Laboratory, Richland, Washington, September 2003. PNNL. 2004. *Hanford Site Environmental Report for Calendar Year 2003*. PNNL-14687, Pacific Northwest National Laboratory, Richland, Washington, September 2004. PNNL. 2005. *Hanford Site Environmental Report for Calendar Year 2004*. PNNL-15222, Pacific Northwest National Laboratory, Richland, Washington, September 2005. PNNL. 2006. *Hanford Site Environmental Report for Calendar Year 2005*. PNNL-15982, Pacific Northwest National Laboratory, Richland, Washington, September 2006. PNNL. 2007. *Hanford Site Environmental Report for Calendar Year 2006*. PNNL-16623, Pacific Northwest National Laboratory, Richland, Washington, September 2007.
Average volumetric flow rate through water body (V_{fx})	1.060×10^{11}	m^3/yr	PNNL. 2002. *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*, PNNL-14027, Pacific Northwest National Laboratory. Richland, Washington (based on 3360 m^3/sec for Priest Rapids)

Table 6-3 Site-Specific Parameters Used in Modeling Surface Water and Sediment

Parameter	Value	Units	Source or Reference
Empirical intercept coefficient (a)	0.6	unitless	Table B-4-14 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Empirical slope coefficient (b)	0.125	unitless	Table B-4-14 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Depth of upper benthic sediment layer (d_{bs})	0.03	m	Table B-4-15 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Depth of water column (d_{wc})	8.65632	m	Columbia Basin Research. 1996. Columbia River Salmon Passage Model CriSP.1.5 Theory, *Calibration & Validation Manual*, Copyright © 1996. Available at http://www.cbr.washington.edu/crisp/models/crisp1manual/theory/theory.mif14.html (Hanford Reach full pool depth at the downstream end of the segment, accessed July 2006.)
Temperature correction factor (θ)	1.026	unitless	Table B-4-19 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Bed sediment porosity (θ_{bs})	0.6	L(water)/ L(sediment)	Table B-4-16 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Soil volumetric water content (θ_{sw})	0.2	mL/cm^3	Table B-1-3 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Current velocity (u)	1.37	m/s	Columbia Basin Research. 1996. Columbia River Salmon Passage Model CriSP.1.5 Theory, *Calibration & Validation Manual*, Copyright © 1996. Available at http://www.cqs.washington.edu/crisp/models/crisp1manual/theory/theory.mif14.html. (Accessed in 2002.) Used John Day Free flow rate of 4.5 ft/sec.

Table 6-4 Site-Specific Modeling Parameters for Estimating Exposure Point Concentrations in Plants

Parameter	Value	Units	Source or Reference
Fraction of COPC wet deposition that adheres to plant surfaces (F_W)	0.2 for anions 0.6 for cations and organics	unitless	Table B-3-7 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Interception fraction of the edible portion of plant (Rp)	0.39	unitless	Section 5.3.1.1 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Interception fraction of the edible portion of forage (Rp_{forage})	0.5	unitless	Section 5.3.1.1 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Interception fraction of the edible portion of fruit (Rp_{fruit})	0.053	unitless	Section 5.3.1.1 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Interception fraction of the edible portion of silage (Rp_{silage})	0.46	unitless	Section 5.3.1.1 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Interception fraction of the edible portion of vegetation (Rp_{veg})	0.982	unitless	Section 5.3.1.1 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC, USA. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Length of plant exposure to deposition per harvest (Tp)	0.164	yr	Calculated value per Eq. 5-16 in EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Length of forage exposure to deposition per harvest (Tp_{forage})	0.12	yr	Section 5.4.1.2 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Length of silage exposure to deposition per harvest (Tp_{silage})	0.16	yr	Section 5.4.1.2 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.

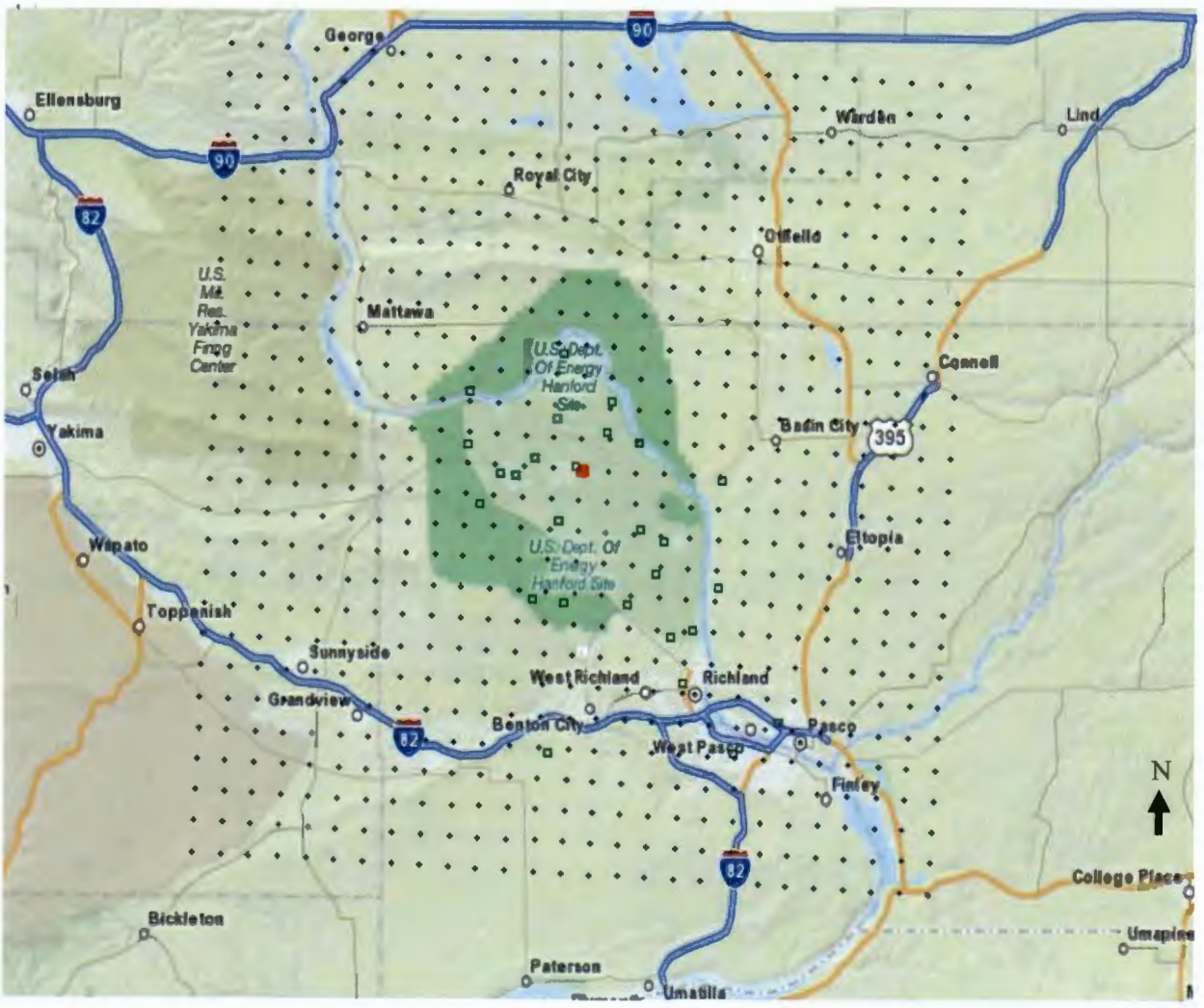
Table 6-4 Site-Specific Modeling Parameters for Estimating Exposure Point Concentrations in Plants

Parameter	Value	Units	Source or Reference
Empirical correction factor for aboveground produce (VG_{ag})	0.01 for $\log K_{ow} > 4$ 1.0 for $\log K_{ow} < 4$	unitless	Section 5.3.2.1 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Empirical correction factor for forage (VG_{ag_forage})	1	unitless	Section 5.4.2.1 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Empirical correction factor for silage (VG_{ag_silage})	0.5	unitless	Section 5.4.2.1 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Correction factor for belowground produce ($VG_{rootveg}$)	0.01 for $\log K_{ow} > 4$ 1.0 for $\log K_{ow} < 4$	unitless	Section 5.3.3 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Yield or standing crop biomass of the edible portion of plant (Yp)	2.24	kg DW/m^2	Section 5.3.1.4 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Yield or standing crop biomass of the edible portion of below-ground produce (Yp_{bg})	0.25	kg DW/m^2	A yield of 600 cwt (WW)/acre (6.72 kg/m^2) was assumed based on USDA 2009 data for potatoes and onions. A conversion factor of 0.173 kg(DW)/kg(WW) (Baes et. al. 1984, Table 2.3, potato and onion average) is applied resulting a dry weight yield of 1.17 kg/m^2
Yield or standing crop biomass of the edible portion of grain (Yp_{grain})	0.25	kg DW/m^2	Baes et al. 1984, Figure 4.14
Yield or standing crop biomass of the edible portion of forage (Yp_{forage})	0.15	kg DW/m^2	Wisiol K. 1984. "Estimating Grazingland Yield from Commonly Available Data," in J. Range Mgmt., Volume 37, Issue 5, p 471-475, September 1984.) Yp_{forage} = (1,500 kg/ha) × (1 ha / 10,000 m^2) = 0.15 kg/m^2 dry weight.

Table 6-4 Site-Specific Modeling Parameters for Estimating Exposure Point Concentrations in Plants

Parameter	Value	Units	Source or Reference
Yield of the edible portion of fruit (Yp_{fruit})	0.25	kg DW/m^2	Section 5.3.1.4 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Yield or standing crop biomass of the edible portion of silage (Yp_{silage})	0.8	kg DW/m^2	Section 5.4.1.4 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Yield or standing crop biomass of the edible portion of vegetation (Yp_{veg})	5.66	kg DW/m^2	Section 5.3.1.4 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Plant surface loss coefficient (kp)	18	yr^{-1}	Section 5.3.1.2 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.
Density of air (ρ_{air})	0.0012	g/cm^3	Table B-4-21 of EPA, 2005, *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, EPA/530/R-05/006, US Environmental Protection Agency, Washington, DC. Available at http://www.epa.gov/epaoswer/hazwaste/combust/risk.htm.

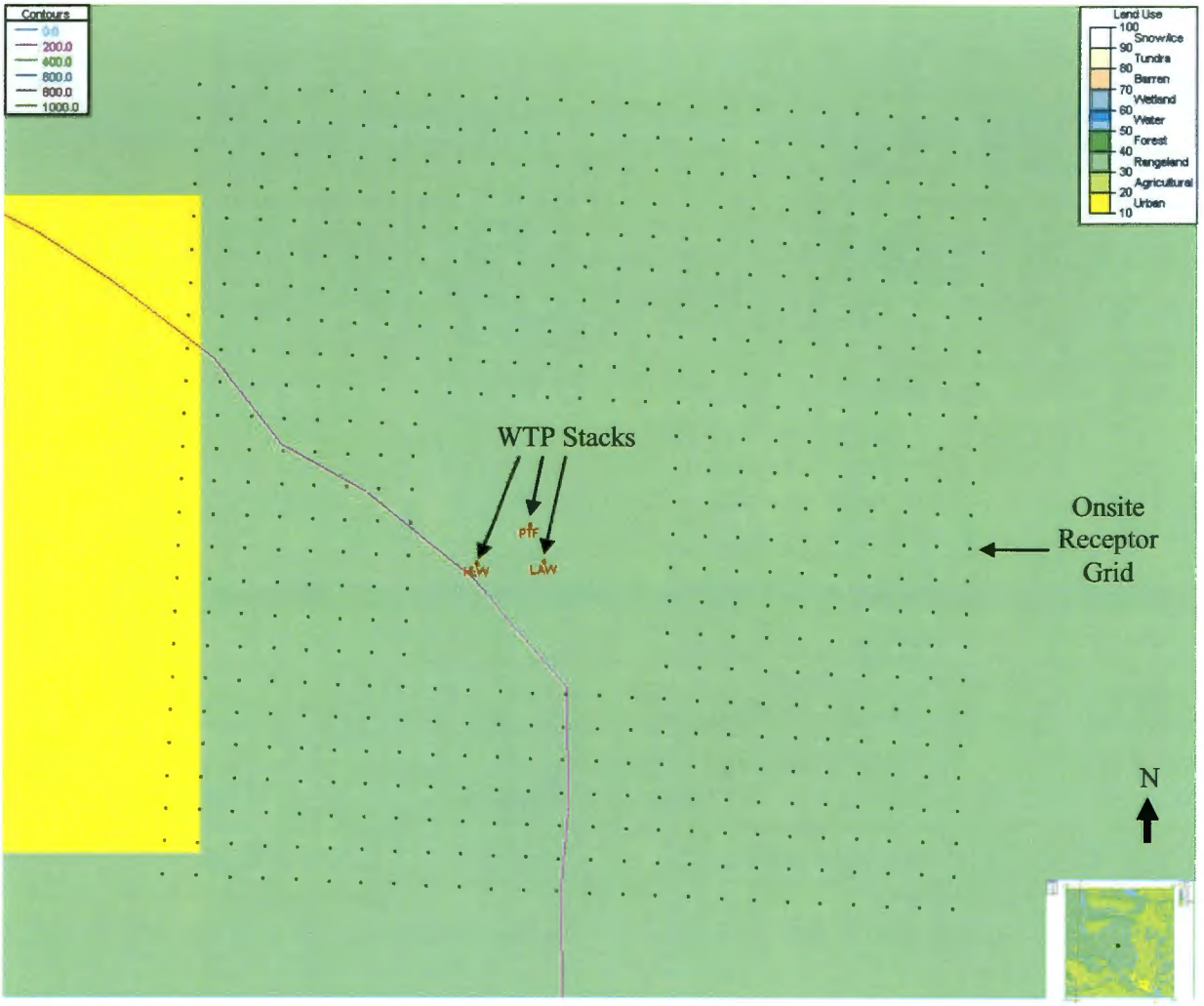
1 **Figure 6-1 CALMET Domain**



2
3

Symbols:
• indicates receptor grid node
□ indicates met station
• indicates WTP location

Figure 6-2 Onsite Receptor Locations



Symbols:
• indicates receptor grid node
• indicates WTP location

Figure 6-3 Offsite Receptor Locations

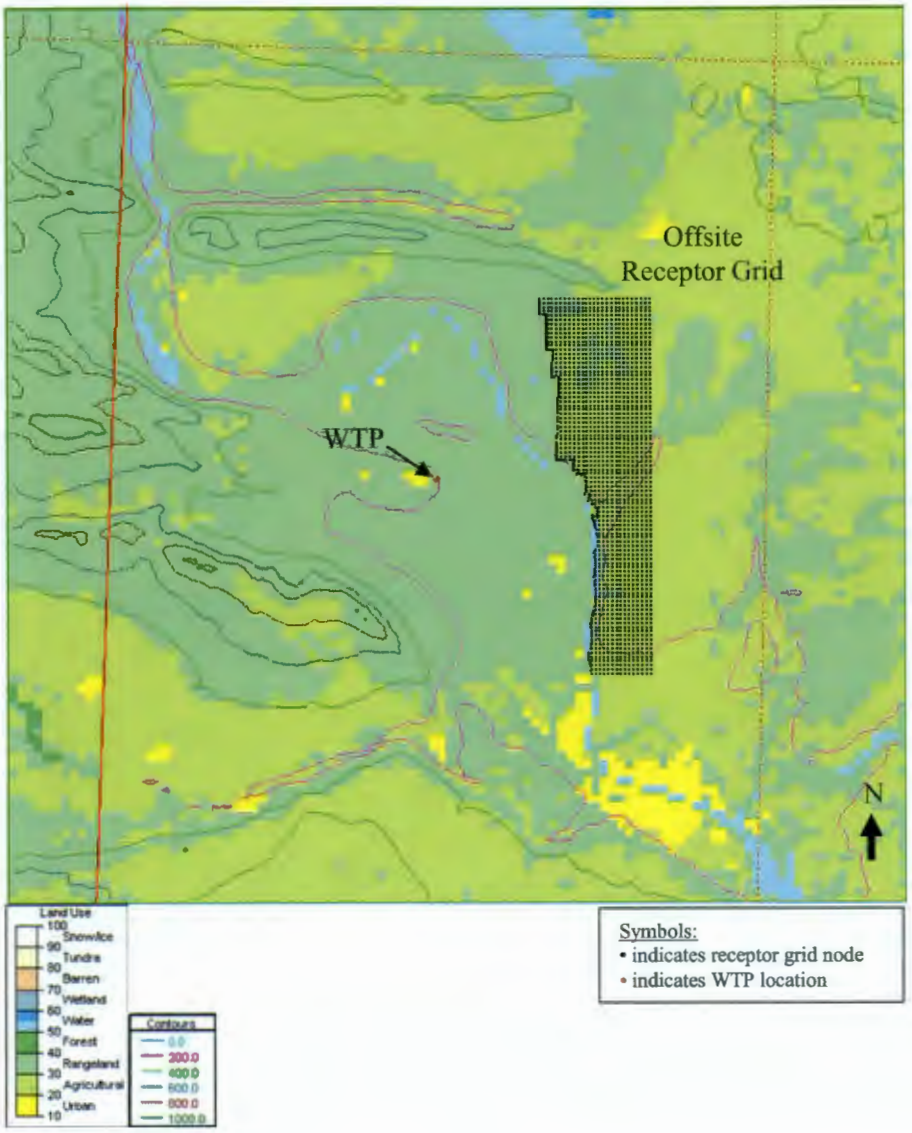


Figure 6-4 Gable Mountain Receptor Locations

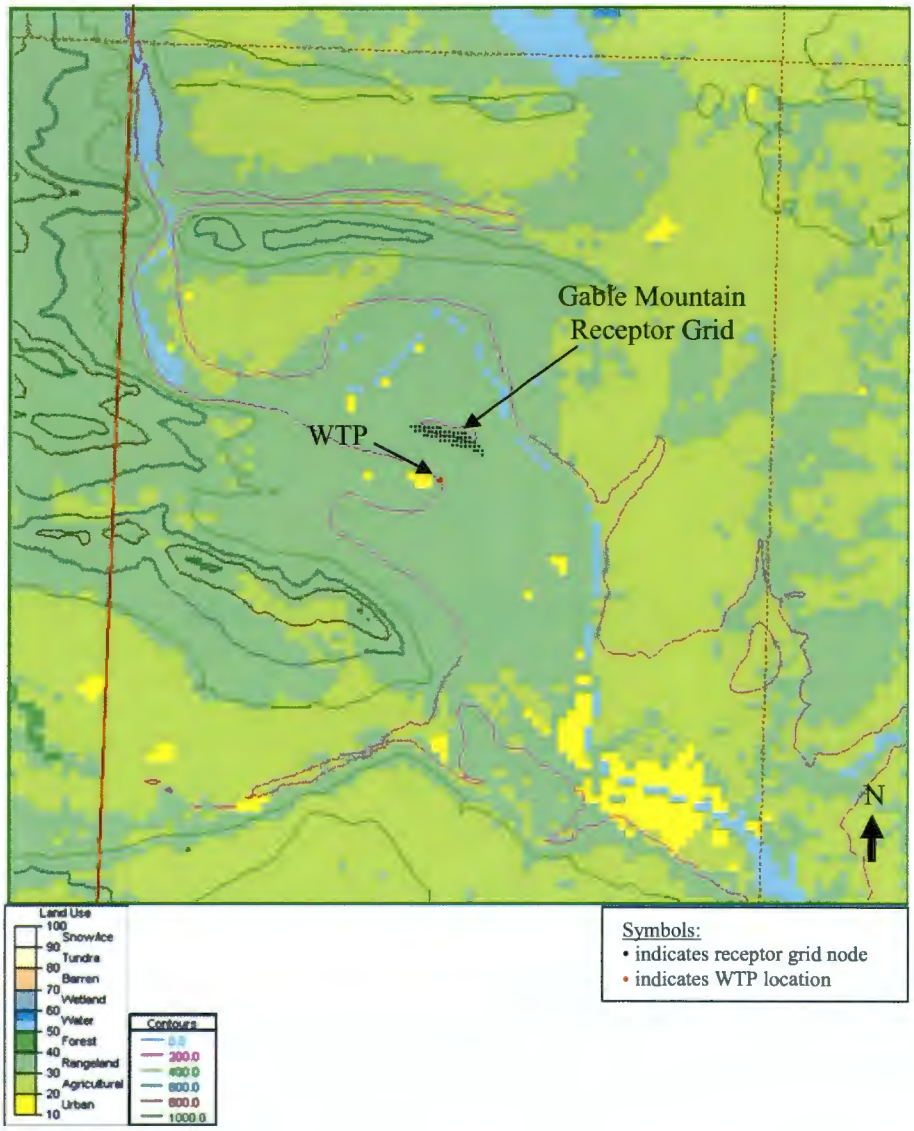


Figure 6-5 Columbia River Receptor Locations

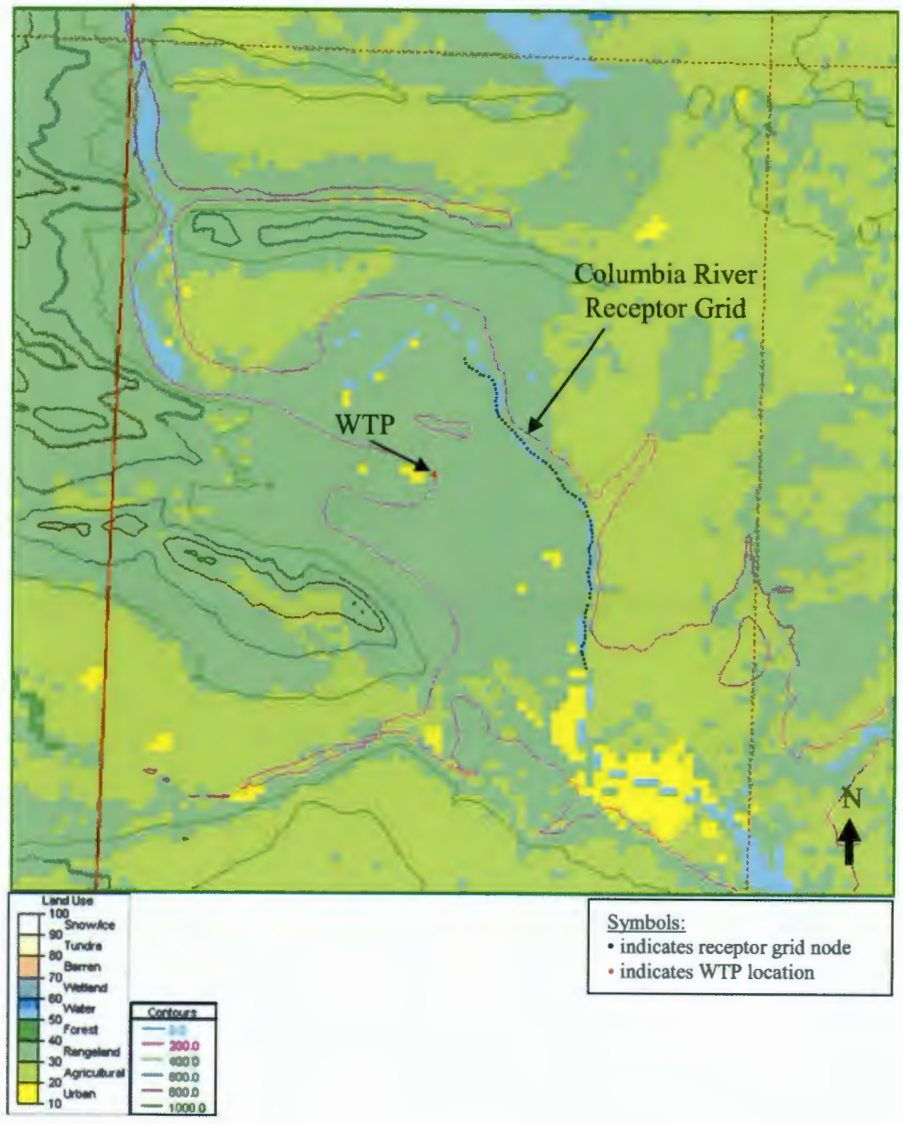


Figure 6-6 Hunter-Gatherer Current Receptor Locations

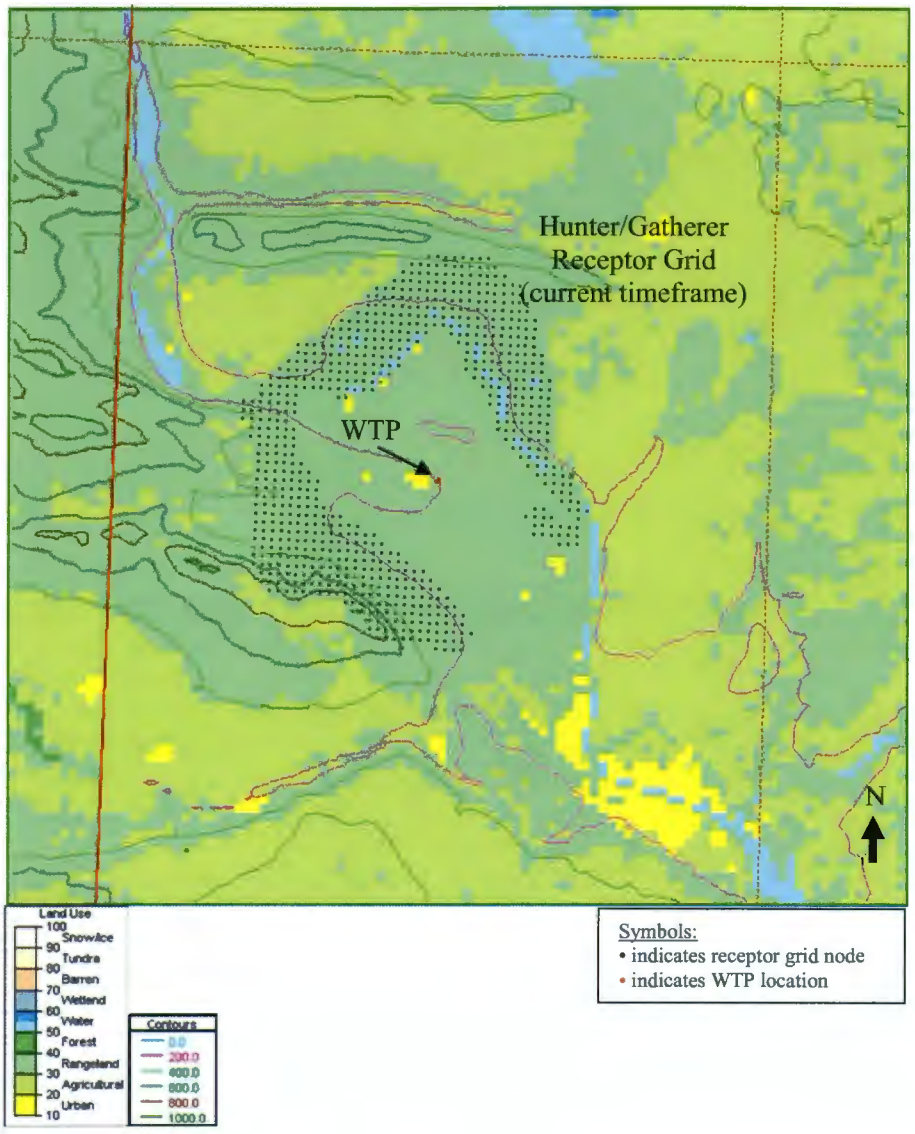
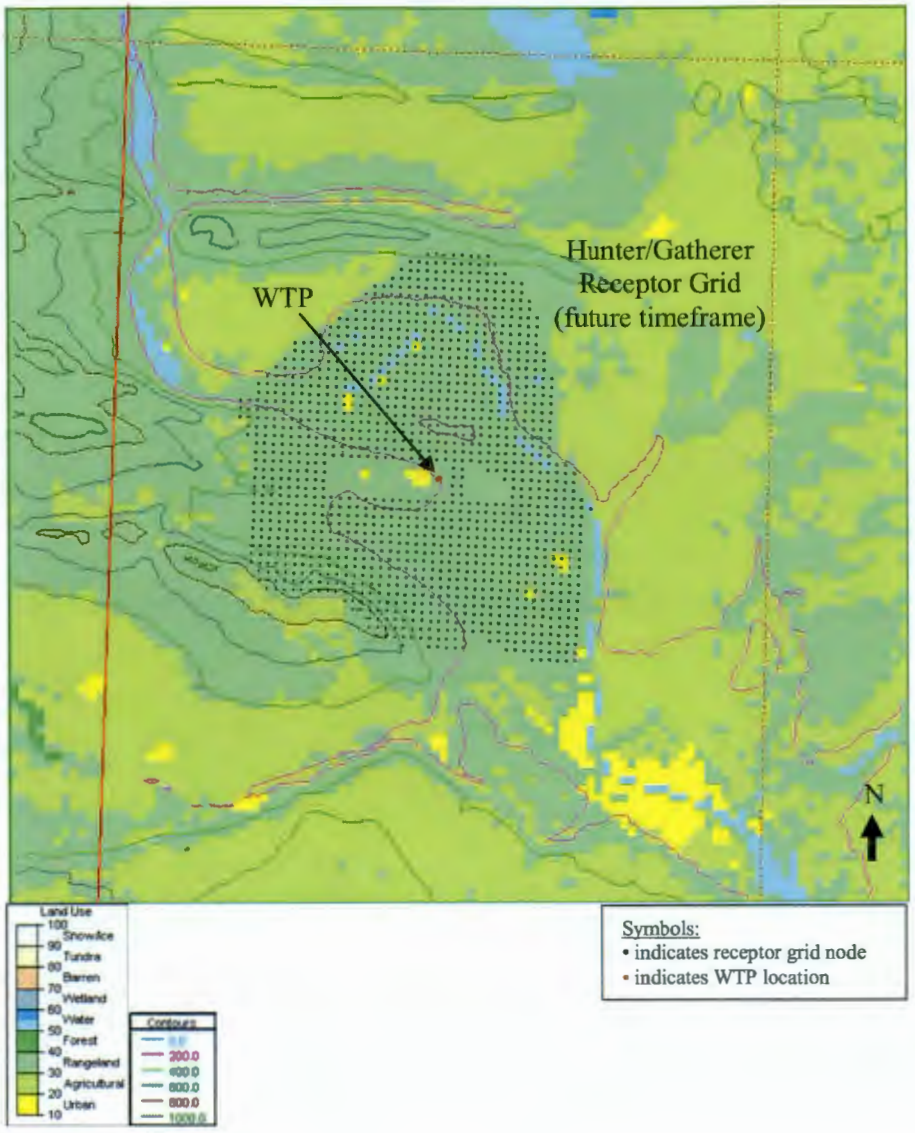
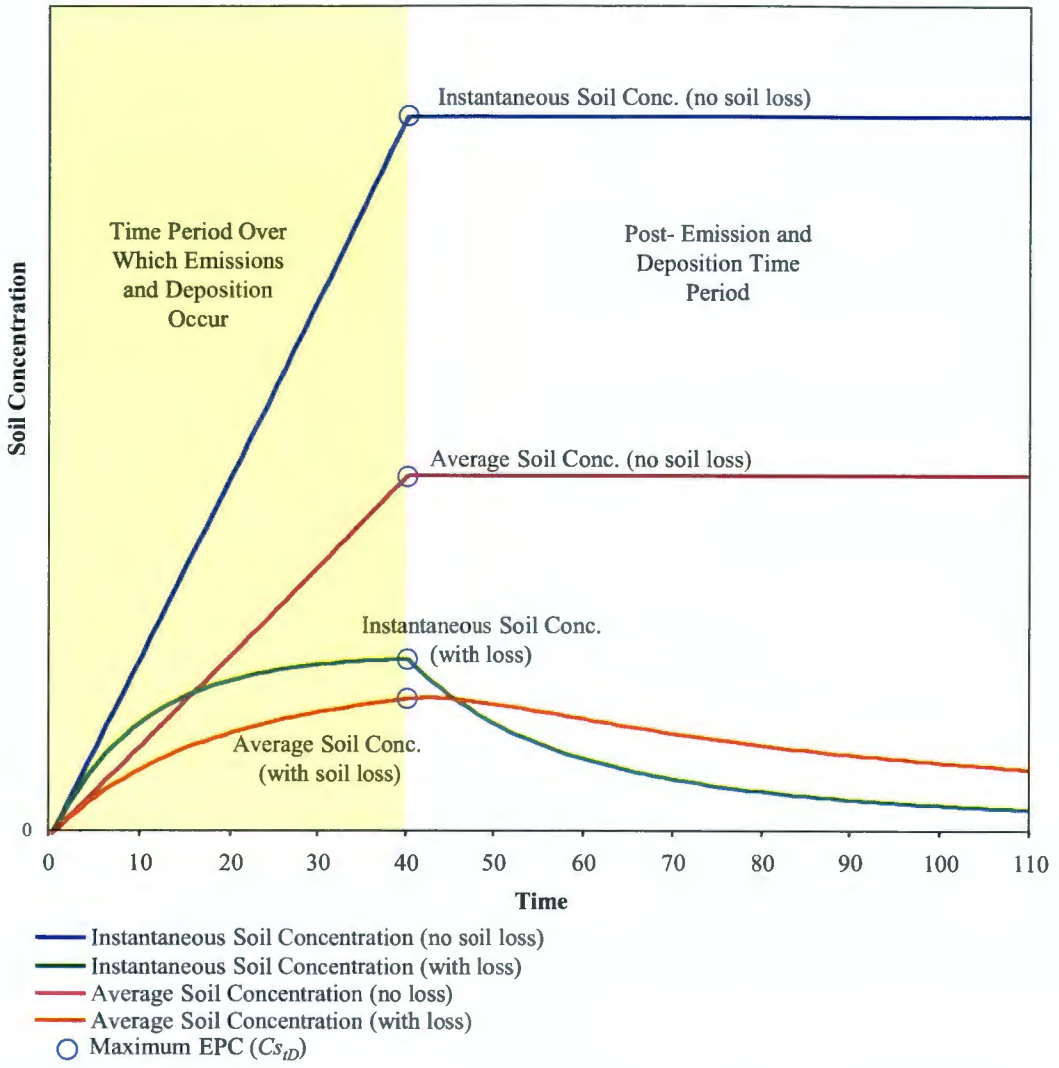


Figure 6-7 Hunter-Gatherer Future Receptor Locations

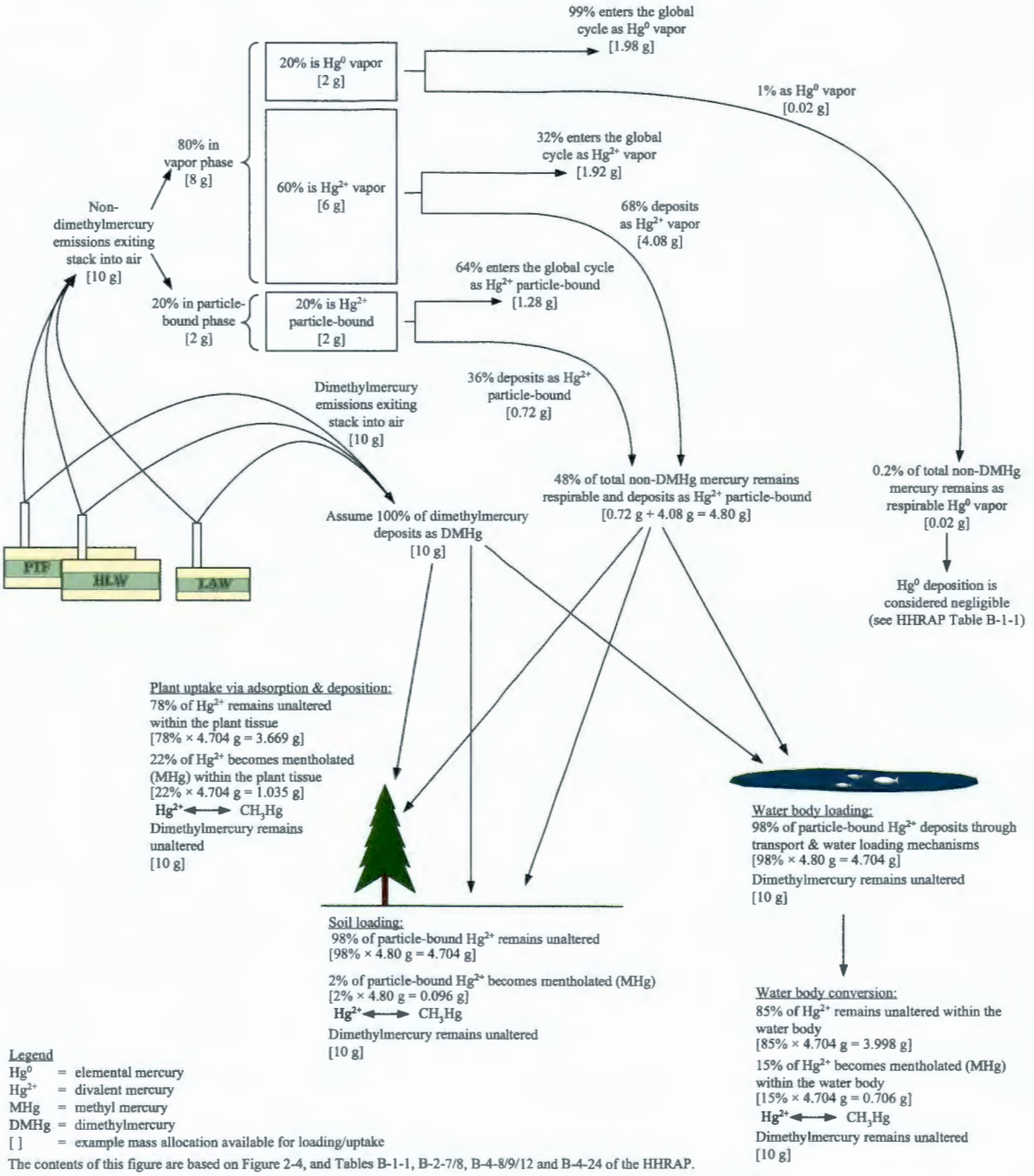


1 **Figure 6-8 Soil Concentration with Time**



2

Figure 6-9 Mercury Emissions Fate and Transport Assumptions



The contents of this figure are based on Figure 2-4, and Tables B-1-1, B-2-7/8, B-4-8/9/12 and B-4-24 of the HHRAP.

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7 Screening Human Health Risk Assessment

The HHRA process includes four fundamental components: (1) data evaluation, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization. The data evaluation step is the selection of COPCs and ROPCs discussed in Section 4 of this work plan, and the quantification of emissions discussed in Section 5. Each of the remaining three components is discussed below:

- Exposure assessment – Section 7.1
- Toxicity assessment – Section 7.2
- Risk characterization – Section 7.4

The SLRA is designed to identify, early in the process, any potential risks associated with the WTP. The SLRA has been designed to overestimate potential risks by using conservative exposure assumptions combined with conservative toxicity values. The HHRA is one part of the SLRA that focuses on human health.

7.1 Exposure Assessment

Exposure assessment is the process of estimating the magnitude, frequency, duration, and type of potential exposures to COPCs and ROPCs. This section presents the exposure scenarios and approach for conducting the quantitative exposure assessment.

A human health conceptual exposure model identifies exposure scenarios that are defined by potentially exposed populations and exposure pathways. The conceptual exposure model used for this work plan is shown as Table 7-1 and was developed from guidance and information obtained from theHHRAP (EPA 2005a), the *Screening Assessment and Requirements for a Comprehensive Assessment: Columbia River Comprehensive Impact Assessment* (DOE-RL 1998), and discussions with DOE-ORP, Ecology, and EPA.

The conceptual exposure model focuses on identifying complete exposure pathways for potentially exposed populations. An exposure pathway is the means through which an individual may come in contact with a chemical in the environment. Exposure pathways are determined by:

- Environmental conditions (such as location of receptors, vegetative cover, and wind speed and direction)
- The potential for chemical migration through environmental media (such as soil, vegetation, or air)
- Lifestyles and work activities of potentially exposed populations

Although several potential pathways may exist, not all may be complete. For a pathway to be complete, all of the following four factors must exist:

- COPC or ROPC release into the environment
- Release and transport mechanism (such as deposition to soil) that moves the COPC or ROPC from the source to other locations
- Point of contact for receptors to be exposed to the affected media

- Exposure pathway, such as breathing vapors or ingesting affected media

These four factors were considered in the development of the conceptual exposure model. The sources of COPC and ROPC release are the WTP stacks. Transport processes, potential points of contact, and complete exposure pathways are identified to formulate exposure scenarios that will be the focus of the quantitative risk assessment. The process of exposure assessment is detailed in the following subsections.

7.1.1 Characterization of Exposure Setting

Characterizing the exposure setting is the first step in identifying potentially exposed populations. This characterization includes identifying the location of human populations within the study area and types of activities that can be expected under current and reasonable potential future land use.

The study area is defined as the area within a 50-km radius of the WTP. While it is possible for human populations to be exposed beyond this 50-km radius, the concentration of airborne and deposited emissions will be orders of magnitude less than those within the study area, essentially approaching zero. The EPA (2005a) reports that at other facilities, the most significant deposition of airborne emissions has been observed within a 3-km radius of a source. The Hanford site boundary extends approximately 9 km to 28 km from the WTP. The Columbia River is located approximately 8 km to more than 20 km from the WTP. Therefore, the potential for offsite impacts is expected to be minimal; however, because of the importance of the Columbia River as a potable water and recreational resource, it will be included in the quantitative risk assessment. Currently, no residential receptors are present on the Hanford site, nor are there likely to be any in the near future (i.e., within the next 50 years). Game animals that graze on Hanford site property and plants that grow on Hanford site property may be harvested by American Indians living off-site.

Characterization of the exposure setting includes the following:

- Characterization of the physical setting, including location of important physical features such as Gable Mountain, surface water bodies, and watersheds
- Characterization of potentially exposed populations, including identifying the location and activity patterns of current populations relative to the facility, determining plausible future land use, and identifying subpopulations of potential concern

Characterization will concentrate on the areas potentially most impacted by emissions, based on the results of the air-dispersion modeling and will include both current and future land use. The exposure assessment will focus on six locations of interest (see Figure 7-1):

- **Onsite ground maximum** – location of maximum predicted ground-level concentrations of both airborne and deposited emissions. This location generally represents worst-case human and ecological exposures because very few receptors are expected to be present here. The onsite ground maximum location is a 100 m × 100 m area represented by the point or points predicted to have the highest concentration of airborne and deposited emissions. The grid covers the area in the immediate region downwind from WTP. Receptors who are likely to receive exposures at this location are limited to onsite workers.
- **Hanford offsite** – location of predicted ground-level concentrations of both airborne and deposited emissions outside the Hanford Site boundary. This location represents a more plausible location for most human receptors and is an important point of compliance. The grid spans a region that is

predominately downwind of the WTP, adjacent to the southeastern border of the site. For conservatism, the residence of all receptors is assumed to occupy this grid.

- **Gable Mountain maximum** – location of maximum predicted ground-level concentrations of both airborne and deposited emissions at Gable Mountain. This location is included due to its importance to American Indian populations in the Oregon-Washington area. For purposes of assessing potential risks due to WTP emissions, Gable Mountain represents a site of tribal ceremonial activities and as such, receptor exposure is generally of a limited duration.
- **Columbia River maximum** – location of maximum predicted ground-level concentrations of both airborne and deposited emissions at the Columbia River. This location is used to evaluate potential risks to aquatic ecological receptors, as a source of potable water for human receptors, and as a source of fish for human receptors. The Columbia River receptor grid is predominately downwind of the WTP in the eastern region of the Hanford Site.
- **Hunter/Gatherer Area I (current timeframe)** – location of predicted ground-level concentrations of both airborne and deposited emissions for grazing game and native plant species. The subsistence resident American Indian is assumed to consume food (wild game, wildfowl, wildfowl eggs, and wild plants) harvested on site. Although the home range of most game and wild fowl is located primarily along the riparian corridor of the Columbia River, deer and other game may browse anywhere on site. The current exposure scenario hunting/gathering area (shown in Figure 7-2) includes the Hanford Reach National Monument and Gable Mountain. This area includes the portions of the Hanford site that could be used for grazing by game animals and wild fowl, and most likely to be used by people for collecting wild plants. It excludes the interior area of the Hanford Site.
- **Hunter/Gatherer Area II (future timeframe)** – expanded location of predicted ground-level concentrations of both airborne and deposited emissions for grazing game and native plant species. The hunter/gatherer receptor grid in the future timeframe is presumed to exist after shutdown of the WTP. Like the current hunting/gathering area assessed in current scenarios, this future area includes the riparian zones along the Columbia River, where game animals and important wild plants are likely to be present, and Gable Mountain. This future area also includes the area of maximum contaminant concentrations near the WTP (see Figure 7-2). This future hunting/gathering area is intended to provide a more conservative estimate of potential exposure and risk by including the area where concentrations are at their maximum. The hunter/gatherer area receptor grid does not include the exclusion area located at Hanford's central plateau or the industrial area east of the plateau. Note that because receptor access to this area is not assumed to occur until after WTP shutdown, exposure to airborne contaminants will not occur since there are no emissions.

Using the highest discrete values of Cyv, Cyp_1, $Cyp_{2.5}$, $Dydv$, $Dydp_1$, $Dydp_{2.5}$, $Dywv$, $Dywp_1$, and $Dywp_{2.5}$ from the offsite, onsite maximum, Columbia River, and Gable Mountain grids will certainly result in the highest degree of conservatism. However, in large receptor exposure grids such as the offsite grid, the corresponding exposures to such extreme deposition and air concentrations are improbable and could result in risk estimates that are highly improbable as well. As a result, the data from CALPOST were evaluated to provide some quantitative information with regard to the potential exposure to extreme air concentrations and depositions, and to aid in determining the appropriate CALPOST data for input in the risk assessment (24590-WPT-RPT-ENV-13-001). It was concluded that the 90th percentile of the predicted ground-level concentrations of both airborne and deposited emissions values for the Hanford offsite receptor exposure grid will sufficiently characterize exposures at that location. The appropriateness of using average deposition values to represent exposures to foods from the hunter/gatherer area was also evaluated. For the very large hunter/gatherer areas (where average exposures are of concern) the distribution-free 95 % upper confidence limit of the median provides a sufficiently conservative estimate of air concentration and deposition. For more localized exposure grids

such as at the onsite ground maximum, Columbia River, and Gable Mountain, the maximum predicted deposition or concentration provides a conservative estimate of exposure.

Figure 7-1 shows the locations of interest that will be the focus of the exposure assessment.

The subsistence resident American Indian is assumed to consume food (wild game, wildfowl, wildfowl eggs, and wild plants) harvested on site. The hunting and gathering areas for the subsistence resident American Indian are based on the following assumptions:

- The various types of plants eaten or used for ceremonial or medicinal purposes are collected from a variety of habitats (such as river corridor, foothills and mountains, meadow, and shrub-steppe). The exact collecting locations and types of plants collected are unknown; however, it is known that Gable Mountain is important for ceremonial activities, and plants are collected approximately once per year at the McGee ranch west of the 200 Areas.
- While onsite hunting is currently limited to the area north of the Columbia River, deer and other game may browse anywhere on site.
- The home range of deer at Hanford is located primarily along the riparian corridor of the Columbia River.
- The traditional subsistence lifestyle is a communal lifestyle; therefore, the hunting and gathering area must support more than a single individual or even a single family.
- A conservative scenario should include the locations of maximum emissions concentrations (ground maximum), and the locations of maximum emissions concentrations where it is known that some important activities occur (Gable Mountain maximum, Columbia River maximum).

To meet these needs, two hunting/gathering areas have been identified as described above. The current exposure scenario hunting/gathering area (shown in Figure 7-2) includes the Hanford Reach National Monument and Gable Mountain. This area includes the portions of the Hanford site most likely to be used for grazing by game animals, and most likely to be used by tribal members for collecting wild plants. The future exposure scenario hunting/gathering area (shown in Figure 7-2) includes the entire Hanford site excluding the 200 Area industrial zones. Like the current hunting/gathering area, this future area includes the riparian zones along the Columbia River, where game animals and important wild plants are likely to be present, and Gable Mountain. This future area also includes the area of maximum contaminant concentrations near the WTP. This future hunting/gathering area is intended to provide a more conservative estimate of potential exposure and risk by including the area where concentrations are at their maximum but food gathering activities are not likely to occur. For both of these hunting/gathering areas (see Figures 6-6 and 6-7) contaminant concentrations in soil will be estimated from an average soil concentration computed using the 95 % upper confidence limit of the median deposition. These soil concentrations will in turn be used to calculate contaminant concentrations in plant and animal tissue.

Receptors, locations, scenarios, and exposure pathways are summarized in Table 7-1.

7.1.2 Identification of Receptor Types

EPA (2005a) recommends that the following receptor types be evaluated for assessing potential risks from thermal treatment facilities:

- Resident (adult and child)

- Subsistence farmer (adult and child)
- Subsistence fisher (adult and child)
- Nursing infant
- Acute risk

The nursing infant scenario is recommended by EPA guidance (EPA 2005a) to address specific concerns regarding exposure to polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs) because these chemicals are known to accumulate in human milk. The EPA guidance recommends inclusion of the nursing infant only for PCDDs/PCDFs; however, coplanar PCBs will also be evaluated for this pathway in the SLRA due to their potential to behave, physiologically, like PCDDs/PCDFs. Because radionuclides are a major component of the waste to be treated at the facility, several ROPCs will also be evaluated for this pathway. The ROPCs strontium (Sr-90), iodine (I-129), and cesium (Cs-134 and Cs-137) will be evaluated for the nursing infant scenario. These radionuclides were selected because they are potentially present in the waste, are judged to have the highest potential for accumulation in milk, and due to their toxicity (CCN 064327). No other ROPCs will be evaluated for the nursing infant scenario, because other ROPCs have not been shown to accumulate in human milk. Not addressing additional COPCs for the nursing infant scenario is a nonconservative uncertainty in the risk assessment. If the potential risks or hazards for other COPCs in other exposure pathways approach unacceptable levels, and the data are available to evaluate infant exposures, further consideration will be given to incorporating those COPCs into the nursing infant scenario. Nursing infant exposure will be evaluated based on intakes for the Hanford site industrial worker, resident adult, resident subsistence farmer adult, resident subsistence fisher adult, and resident subsistence American Indian adult.

For purposes of this workplan, special subpopulations are defined as individual human beings or subsets of the general population that may potentially be at higher risk due to lifestyle activities that cause higher exposures to COPCs and ROPCs. To address potentially sensitive subpopulations, the following additional exposure scenarios will be evaluated:

- Hanford site industrial worker
- A resident subsistence American Indian (adult and child)

Workers employed at the WTP will not be included in the risk assessment because other regulations exist for occupational exposures within the WTP boundary (e.g., DOE standards for occupational safety and health). However, because of the WTP's location within the Hanford site, the closest and most likely receptors are other Hanford site workers located outside the WTP boundary. Therefore, the Hanford site industrial worker scenario will be included in the risk assessment.

American Indian tribes (Nez Perce Tribe, Yakama Indian Nation, and CTUIR) ceded the land currently occupied by the US government's Hanford site. However, these tribes retained the rights to the use of resources on this land. Representatives of these tribes have expressed a desire to be able to use this land to conduct a traditional lifestyle. A wide range of possible tribal activities related to traditional lifestyles exists. The resident subsistence American Indian scenario will address a variety of potential exposures associated with food gathering (including hunting, fishing, and plant gathering), as well as cultural and social activities (e.g., use of a sweat lodge).

The exposure scenarios included in the quantitative risk assessment are designed to cover a wide range of possible receptor activities, age groups, and lifestyles. These receptors represent the most highly exposed

populations that could work or live near the Hanford site, including adult workers, adult and child residents and farmers, and American Indians living a traditional lifestyle. The exposure assessment and risk characterization results for the selected receptors are designed to be protective of other populations and special subpopulations of interest. For example, the resident child receptor provides a bounding estimate for other child activities, such as children attending school or daycare. This scenario assumes a high level of potential exposure (e.g., the resident child is present 7 days per week, 24 hours per day and ingests homegrown produce) at an offsite location of elevated contaminant concentration. Hence, risk-management decisions based on these conservative assumptions will be protective of other child populations (e.g., at a school or daycare center where exposure would be less because a child may be present 5 days per week for less than 12 hours per day). Other possible special subpopulations are being evaluated by identifying their locations and determining whether they are located in areas that are potentially at risk from WTP emissions. Figure 7-3 provides a map showing (1) the location of the WTP, (2) the locations of potential receptor populations (such as cities), and (3) locations of potentially sensitive subpopulations (such as daycare centers and preschools, schools, hospitals, and nursing homes). Figure 7-4 summarizes the receptors, locations, exposure scenarios, and exposure pathways.

7.1.3 Description of Exposure Scenarios

Exposure scenarios to be addressed by the risk assessment are described in more detail below and are summarized in Table 7-1. Exposure scenarios are defined for current and future land-use conditions. For the SLRA, *current* and *future* are defined as follows:

Current Land Use. For this work plan, *current* is defined as the 40-year operating lifetime of the WTP, anticipated to begin by 2019. This period corresponds approximately to the period addressed by the *Final Hanford Comprehensive Land-Use Plan (CLUP) Environmental Impact Statement* (DOE 1999) of at least 50 years from publication of the Record of Decision (ROD) (Federal Register 1999 [64 FR 61615]), that is, 1999 through 2049.

Current land use within the 50 km study area is characterized based on aerial photographs, zoning maps, land development plans, and information presented in the CLUP and the preferred land use alternative identified in *Record of Decision (ROD): Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (64 FR 61615).

Figure 7-5 shows existing land use within the study area as of 1996 (DOE 1999). Figure 7-6 shows current (i.e., over approximately the next 40 years) land use on the Hanford Site as defined by the CLUP. Representatives of the Nez Perce Tribe, Yakama Indian Nation, and CTUIR are also being consulted in evaluating current land use in the study area.

Future Land Use. For this work plan, future exposure scenarios begin after WTP shutdown (following 40 years of operation). For example, the future resident subsistence farmer is assumed to be exposed from year 40 to year 80.

Plausible future land use is characterized based on information presented in the documents listed above. Representatives of the Nez Perce Tribe, Yakama Indian Nation, and CTUIR are also being consulted in evaluating future land use in the study area.

In addition to the information in DOE 1999, DOE has indicated that:

- The 200 Areas (a.k.a. central plateau) will remain industrial past the 50-year timeframe of the CLUP because mixed waste has been, and will continue to be, buried there as a result of remedial activities at the rest of the Hanford site.
- There will not be any onsite residential development (within the Hanford site boundary) in the foreseeable future

Both current and future land-use assumptions must also consider the newly created Hanford Reach National Monument, which includes the Saddle Mountain National Wildlife Refuge north of the Columbia River and the Fitzner-Eberhardt Arid Lands Ecology (FEALE) Reserve in the western portion of the Hanford Site.

Within these timeframes, exposure scenarios may be classified as being either plausible or worst-case as defined below.

Plausible exposure scenarios represent receptors that currently exist, or may reasonably be expected to exist, at a given location. For example, workers are currently present in the 200 Areas; therefore, the Hanford site industrial worker is a current plausible exposure scenario at that location. This does not mean that the exposure scenario as described here (a worker present at the point of maximum emissions concentration, 8 hours per day, 250 days per year, for 20 years) portrays actual current workers, but rather, that this type of receptor (onsite worker) is plausible at that location.

Worst-case exposure scenarios represent receptors that are not reasonably expected to exist now or in the future at the specified location. For example, a resident subsistence farmer will be evaluated as a future worst-case receptor at the point of elevated offsite emissions concentrations, but it is unlikely that such a receptor (a totally self-sustaining farmer) will ever exist at this location.

7.1.3.1 Hanford Site Industrial Worker

General Description

This receptor is an adult worker employed near the WTP and living offsite. Workers employed at the WTP will not be included in the risk assessment because other regulations exist for occupational exposures within the WTP boundary (such as DOE standards for occupational safety and health). The Hanford site industrial worker will be evaluated using occupational exposure assumptions primarily from DOE-RL 1995 and residential exposure assumptions primarily from EPA (2005a, 2003, CCN 063810, CCN 063807, CCN 063805, CCN 064331, CCN 063806, CCN 063816), as described in Section 7.1.6.

Exposure Pathways

The Hanford site industrial worker is exposed on site (during work hours) through inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, and external exposure to radionuclides in air and soil. This worker is also assumed to be exposed while at home through these same pathways and through ingestion of homegrown produce.

Exposure Location

This receptor is assumed to work at the onsite ground maximum. The onsite ground maximum location is a 100 m × 100 m area (defined in Section 6.1) represented by the point or points predicted to have the highest concentration of airborne and deposited emissions. This receptor is assumed to live within the Hanford offsite receptor exposure grid. This offsite location is a 500 m × 500 m area represented by the

90th percentile of airborne and deposited emissions. The Hanford site industrial worker is assumed to obtain drinking water from the Columbia River maximum. Exposure of a Hanford site industrial worker is considered a plausible scenario since workers are present in this area and may live off site.

Current Exposure Timeframe

The Hanford site industrial worker is assumed to have a 20-year career. It is also assumed that a retired worker will live within the offsite location for 10 years after retirement. The retiree is assumed to be exposed through the same exposure pathways experienced by a worker while at home when not working. However, it is not necessarily assumed that the worker and the retiree are the same individual. A conservative approach to assessing potential risk is to assume that both the worker and retiree are exposed during the time of maximum potential soil concentration. Recall from Section 6.2 that the time of maximum potential soil concentration occurs at plant shutdown after 40 years of deposition. Thus, it is assumed that for a plant operating from year 0 to year 40, the Hanford site industrial worker is assumed in the current scenario to be exposed from years 20 to 40. Likewise, the retired worker is assumed to be exposed from year 30 to 40 (refer to Figure 7-7). For simplicity, the risk to the worker and retiree will be added and compared to thresholds. If an exceedance occurs, the individual risks of the worker and retiree will be reported and compared to applicable thresholds.

The worker is assumed to be at work (onsite maximum) for 8 hours each weekday (excluding holidays and yearly vacation), resulting in an exposure frequency of 250 days/year. The worker is assumed to be at home (offsite) during the remaining 16 hours of the workday. Additionally, the worker is assumed to spend a cumulative 100 days at home (offsite) each year during weekends. It is assumed that the worker is neither at work nor home for 15 days/year, presumably on holiday and/or vacation outside of the area of assessment. Unlike the worker, the retiree is assumed to spend 24 hours/day, 350 days/year at home and 15 days/year on holiday and/or vacation outside of the area of assessment.

Future Exposure Timeframe

As stated previously, the Hanford site industrial worker is assumed to have a 20-year exposure and the retiree a 10-year exposure. From Section 6.2 the time of maximum potential soil concentration occurs at plant shutdown after 40 years of deposition, and that soil concentrations then gradually decrease due to soil loss. The conservative approach is to assume that both the worker and retiree are exposed immediately after plant shutdown. The Hanford site industrial worker is assumed to be exposed from years 40 to 60 in the future scenario. The retired worker is assumed to be exposed from year 40 to 50.

Worker and retiree exposure time (hours per day) and frequency (days per year) are the same as the current exposure scenario.

7.1.3.2 Nursing Infant of Hanford Site Industrial Worker

General Description

The nursing infant of the Hanford site industrial worker is the infant of the worker described above.

Exposure Pathways

The nursing infant of the Hanford site industrial worker is assumed to be exposed to PCDDs/PCDFs, PCBs, and four ROPCs through ingestion of breast milk from the worker exposed through:

- Inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, and external exposure to radionuclides in air and soil while at work

- Inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, external exposure to radionuclides in air and soil, and ingestion of homegrown produce while at home

Exposure Location and Timeframe

The nursing infant of the Hanford site industrial worker is assumed to reside with the worker described above at the Hanford offsite receptor exposure grid. It is assumed that the mother continues to work during the period of nursing and is exposed to the onsite maximum during the workday, and is exposed offsite while at home. Likewise, the timeframe for exposure of the lactating mother is assumed to be the same as the current worker (years 20 to 40). The timeframe for exposure of the lactating mother in a future exposure scenario is assumed to be the same as the future worker (years 40 to 60). Exposure assessment for the nursing infant does not include an assessment of intake from retired individuals. The current and future exposure of a nursing infant of the Hanford site industrial worker is considered a plausible scenario since workers are present in this area and may live (be a resident) off site.

7.1.3.3 Resident

General Description

The resident is assumed to live, work, and play at a single location and, thus, is assumed to be home 24 hours per day, 350 days per year, with 2 weeks per year on vacation or otherwise away from the home. This receptor is assumed to have a garden that supplies fruit and vegetables. Both an adult and a child resident will be evaluated using EPA default (2005a) and other EPA-recommended (CCN 063810, CCN 063807, CCN 063805, CCN 063806) exposure assumptions described in Section 7.1.6.

Exposure Pathways

The resident (adult and child) is assumed to be exposed through direct inhalation of airborne emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, external exposure to radionuclides in air and soil, and ingestion of homegrown produce. This receptor is assumed to have a garden that supplies homegrown fruit and vegetables. The resident is assumed to obtain drinking water from the point of maximum concentration in the Columbia River.

Exposure Location

The closest resident at the time of this work plan (2013) is located more than 20 km from the WTP. However, in this work plan, *current* is defined as the 40-year operating lifetime of the WTP (approximately beginning in 2019). Therefore, it is assumed that a current resident may be located within the Hanford offsite receptor exposure grid sometime during this 40-year period. This offsite location is a 500 m × 500 m area represented by the 90th percentile of airborne and deposited emissions. The resident is assumed to obtain drinking water from the point of maximum concentration in the Columbia River. Exposure of a resident at the Hanford offsite maximum is considered a plausible scenario since residents are present outside the site boundary and residential development could occur within the offsite grid within the next 40 years.

Current Exposure Timeframe

The resident is assumed to have a 30-year exposure duration. Since the time of maximum potential soil concentration occurs at plant shut down after 40 years of deposition, it is assumed that for a plant operating from year 0 to 40, the resident is assumed to be exposed from years 10 to 40 in the current

scenario. Likewise, the resident child, who has a 6-year exposure duration, is assumed to be exposed from years 34 to 40 in the current scenario (child and adult are not necessarily the same individual).

The resident (adult and child) is assumed to be exposed 24 hours/day, 350 days/year (15 days/year on holiday and/or vacation outside of the area of assessment).

Future Exposure Timeframe

Since the resident is assumed to have a 30-year exposure duration, the future resident is assumed to be exposed from years 40 to 70. The resident child, who has a 6-year exposure duration, is assumed to be exposed from years 40 to 46 in the future scenario (child and adult are not necessarily the same individual).

The resident (adult and child) exposure time (hours per day) and frequency (days per year) are the same as the current exposure scenario.

7.1.3.4 Nursing Infant of Resident

General Description

The nursing infant of the resident is the infant of the adult resident described above.

Exposure Pathways

The nursing infant of the resident is assumed to be exposed to PCDDs/PCDFs, PCBs, and four ROPCs through ingestion of breast milk from the adult resident exposed through inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, and ingestion of homegrown produce.

Exposure Location and Timeframe

The nursing infant of the resident is assumed to reside with the resident described above at the Hanford offsite location during the same period of resident exposure. The timeframe for exposure of the lactating mother is assumed to be the same as the current resident (years 10 to 40). The timeframe for exposure of the lactating mother in a future exposure scenario is assumed to be the same as the future resident (years 40 to 70). The current and future exposure of a nursing infant of the resident within the Hanford offsite receptor exposure grid is considered a plausible scenario since residents are present outside the site boundary and residential development could occur offsite within the next 40 years.

7.1.3.5 Resident Subsistence Farmer

General Description

The resident subsistence farmer is assumed to live, work, and play at a single location (i.e., the resident farmer is assumed to be at home 24 hours per day, 350 days per year, with 2 weeks per year on vacation or otherwise away from the home). This receptor is assumed to maintain a farm that supplies his or her produce (fruit and vegetable), meat (beef, pork, and poultry), dairy products, and eggs. Both an adult and a child resident subsistence farmer will be evaluated using EPA default (2005a) and other EPA-recommended (CCN 063807, CCN 064331, CCN 063806, CCN 063804) exposure assumptions described in Section 7.1.6.

Exposure Pathways

The resident subsistence farmer (adult and child) is assumed to be exposed through inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, external exposure to radionuclides in air and soil, and ingestion of homegrown produce, beef, pork, poultry, dairy products, and eggs.

Exposure Location

The closest resident at the time of this work plan (2011) is located more than 20 km from the WTP. However, in this work plan, *current* is defined as the 40-year operating lifetime of the WTP (beginning in approximately 2019). Therefore, it is assumed that a current resident subsistence farmer may be located at the Hanford offsite receptor exposure grid. This offsite location is a 500 m × 500 m area represented by the 90th percentile of airborne and deposited emissions. The resident subsistence farmer is assumed to obtain drinking water from the point of maximum concentration in the Columbia River. Exposure of a resident subsistence farmer at the Hanford offsite location is considered a worst-case scenario because, while resident farmers may be present outside the site boundary, the defined exposure scenario (i.e., a farmer producing his or her own food, as described in Section 7.1.6.2, within a 500 m × 500 m area) is unlikely.

Current Exposure Timeframe

The resident subsistence farmer is assumed to have a 40-year exposure duration. Since the time of maximum potential soil concentration occurs at plant shut down after 40 years of deposition, it is assumed that for a plant operating from year 0 to 40, the resident subsistence farmer is assumed to be exposed throughout the entire duration of plant operation (years 0 to 40). The resident subsistence farmer child, who has a 6-year exposure duration, is assumed to be exposed from years 34 to 40 in the current scenario (child and adult are not necessarily the same individual).

The resident subsistence farmer (adult and child) is assumed to be exposed 24 hours/day, 350 days/year (15 days/year on holiday and/or vacation outside of the area of assessment).

Future Exposure Timeframe

Since the resident subsistence farmer is assumed to have a 40-year exposure duration, the future resident subsistence farmer is assumed to be exposed from years 40 to 80. The resident subsistence farmer child, who has a 6-year exposure duration, is assumed to be exposed from years 40 to 46 in the future scenario (child and adult are not necessarily the same individual).

The resident subsistence farmer (adult and child) exposure time (hours per day) and frequency (days per year) are the same as the current exposure scenario.

7.1.3.6 Nursing Infant of Resident Subsistence Farmer

General Description

The nursing infant of the resident subsistence farmer is the infant of the adult resident subsistence farmer described above.

Exposure Pathways

The nursing infant of the resident subsistence farmer is assumed to be exposed to PCDDs/PCDFs, PCBs, and four ROPCs through ingestion of breast milk from the adult resident subsistence farmer exposed through inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, and ingestion of homegrown produce, beef, pork, poultry, dairy products, and eggs.

Exposure Location

The nursing infant of the resident subsistence farmer is assumed to reside with the resident subsistence farmer described above within the Hanford offsite receptor exposure grid during the same period of resident subsistence farmer exposure. The current and future exposure of a nursing infant of the resident subsistence farmer at the Hanford offsite location is considered a worst-case scenario because, while resident farmers may be present outside the site boundary, the defined exposure scenario (i.e., an infant nursed for one year by a farmer producing her own food at a single grid node) is unlikely.

7.1.3.7 Resident Subsistence Fisher

General Description

The resident subsistence fisher scenario is the same as the resident scenario with the addition of fish ingestion. This receptor is assumed to live, work, and play at a single location (i.e., the resident fisher is assumed to be at home 24 hours per day, 350 days per year, with 2 weeks per year on vacation or otherwise away from the home). This receptor is assumed to have a garden that supplies fruit and vegetables and to obtain fish from the Columbia River. Both an adult and a child resident subsistence fisher will be evaluated using the EPA default (2005a) and other EPA-recommended (CCN 063810, CCN 063807, CCN 063805, CCN 063806) exposure assumptions described in Section 7.1.6.

Exposure Pathways

The resident subsistence fisher (adult and child) is assumed to be exposed through inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, external exposure to radionuclides in air and soil, ingestion of homegrown produce, and ingestion of locally caught fish.

Exposure Location

The closest resident at the time of this work plan (2013) is located more than 20 km from the WTP. However, for this risk assessment work plan (RAWP), *current* is defined as the 40-year operating lifetime of the WTP (beginning in approximately 2019). Therefore, it is assumed that a current resident subsistence fisher may be located at the Hanford offsite receptor exposure grid sometime during this 40-year period. This offsite location is a 500 m × 500 m area represented by the 90th percentile of airborne and deposited emissions. The resident subsistence fisher is assumed to obtain drinking water and fish from the point of maximum concentration in the Columbia River. Exposure of a resident subsistence fisher within the Hanford offsite exposure grid is considered a worst-case scenario because, while residents might be present outside the site boundary and fish the Columbia River, the defined exposure scenario (i.e., a fisher growing fruit and vegetables and ingesting locally caught fish every day) is unlikely.

Current Exposure Timeframe

The resident subsistence fisher is assumed to have a 30-year exposure duration. Since the time of maximum potential soil concentration occurs at plant shut down after 40 years of deposition, it is assumed

that for a plant operating from year 0 to 40, the resident subsistence fisher is assumed to be exposed from years 10 to 40. The resident subsistence fisher child, who has a 6-year exposure duration, is assumed to be exposed from years 34 to 40 in the current scenario (child and adult are not necessarily the same individual).

The resident subsistence fisher (adult and child) is assumed to be exposed 24 hours/day, 350 days/year (15 days/year on holiday and/or vacation outside of the area of assessment).

Future Exposure Timeframe

Since the resident subsistence fisher is assumed to have a 30-year exposure duration, the future resident subsistence fisher is assumed to be exposed from years 40 to 70. The resident subsistence fisher child, who has a 6-year exposure duration, is assumed to be exposed from years 40 to 46 in the future scenario (child and adult are not necessarily the same individual).

The resident subsistence fisher (adult and child) exposure time (hours per day) and frequency (days per year) are the same as the current exposure scenario.

7.1.3.8 Nursing Infant of Resident Subsistence Fisher

General Description

The nursing infant of the resident subsistence fisher is the infant of the adult resident subsistence fisher described above.

Exposure Pathways

The nursing infant of the resident subsistence fisher is assumed to be exposed to PCDDs/PCDFs, PCBs, and four ROPCs via ingestion of breast milk from the adult resident subsistence fisher exposed via inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, external exposure to radionuclides in air and soil, ingestion of homegrown produce, and ingestion of locally caught fish.

Exposure Location

The nursing infant of the resident subsistence fisher is assumed to reside with the resident subsistence fisher described above within the Hanford offsite receptor exposure grid during the same period of resident subsistence fisher exposure. The current and future exposure of a nursing infant of the resident subsistence fisher within the Hanford offsite location is considered a worst-case scenario as described above for the resident subsistence fisher.

7.1.3.9 Resident Subsistence American Indian

General Description

The resident subsistence American Indian refers to the American Indian hunter-gatherer exposure scenario originally developed for the *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site* (TC&WM EIS, DOE 2012), adapted for the WTP risk assessment. The American Indian scenario exposure parameters presented in the TC&WM EIS were used where available. Other parameters were taken from the *Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement* (TWRS EIS, DOE 1996) or from EPA's *Exposure*

Factors Handbook (EFH[1], EPA 1997a). Children's exposure parameters were developed by proportioning the child caloric intake reported in EPA guidance (*Child-Specific Exposure Factors Handbook* [CSEFH, EPA 2008]), according to the various proportions of meat, vegetable, roots, etc. in the diet of the adult American Indian as reported in the TC&WM EIS.

The resident subsistence American Indian is assumed to live a traditional subsistence lifestyle. The traditional lifestyles of the Nez Perce, Yakama Indian Nation, and CTUIR were historically based on a seasonal cycle of travel among hunting, plant gathering, and fishing areas. The most common foods were salmon, roots (including camas bulb, bitterroot, wild carrot, and wild potato), berries (including service berries, gooseberries, huckleberries, chokecherries, and wild strawberries), deer, and elk. Each of these foods was collected in different locations during different seasons. The seasonal cycle of food gathering encompassed a large area including the lowlands along the Columbia River and its tributaries, foothills, and prairies, and higher mountainous areas. Presently, tribal members may hunt in areas such as the North Slope (a.k.a. Saddle Mountain National Wildlife Refuge, north of the Columbia River), fish near the Vernita bridge (where the Columbia River enters the western boundary of the Hanford site), and occasionally gather food at sites such as the McGee ranch (south of the Columbia River at the western boundary of the Hanford site). Members of the three tribes potentially impacted at Hanford would be individuals pursuing a traditional lifestyle. The traditional lifestyle of these three tribes is heavily dependent on fish (primarily salmon) in addition to game and plants; therefore, a separate hunter/gatherer and fisher would not exist. A more realistic receptor is a combination hunter/gatherer/fisher.

The resident subsistence American Indian is assumed to hunt and fish to supply his or her meat (game and wildfowl), egg (from wildfowl), and fish needs, and to gather native plants to supply his or her fruit and vegetable needs. Both an adult and a child resident subsistence American Indian will be evaluated.

Exposure Pathways

The resident subsistence American Indian (adult and child) is assumed to be exposed through inhalation of emissions; ingestion of soil; inhalation of resuspended soil; ingestion of drinking water; external exposure to radionuclides in air and soil; and ingestion of wild plants, game, wildfowl, fish, and wildfowl eggs. The consumption of livestock, dairy products, and domestic produce does not occur in this scenario. In addition to these pathways, the resident subsistence American Indian is also assumed to be exposed through inhalation and dermal exposure to resuspended constituents from water in a sweat lodge.

Exposure Location

The resident subsistence American Indian is assumed to live offsite within the Hanford offsite receptor exposure grid, consume fish from the Columbia River maximum, and consume wild game, wildfowl, wildfowl eggs, and plants harvested on the hunting/gathering area. The resident subsistence American Indian is also assumed to obtain drinking water and water for use in a traditional sweat lodge from the Columbia River maximum. The locations for each of these activities are described in more detail in Section 7.1.1.

The resident subsistence American Indian is assumed to live a traditional subsistence lifestyle, based on seasonal hunting, plant gathering, and fishing. This receptor is assumed to live, work, and play at a single

[1] The 1997 version of the *Exposure Factors Handbook* was the version available at the time of the development of this RAWP. In October 2011, EPA released *Exposure Factors Handbook: 2011 Edition*. Data from this later version will be used to supersede like data from the 1997 version (as needed) as part of the FRA. This update is not anticipated to significantly alter the risk assessment results.

location continuously (i.e., the resident subsistence American Indian is assumed to be at home 24 hours per day, 365 days per year). It is assumed that the resident subsistence American Indian's home is located within the offsite receptor grid. This offsite location is a 500 m × 500 m area represented by the 90th percentile of airborne and deposited emissions.

It is also assumed that consumption of food (wild game, wildfowl, wildfowl eggs, and wild plants) from the hunter/gatherer location, and consumption of fish from the Columbia River maximum, occur every day (365 days/year). The current and future hunting and gathering areas are defined as described above and shown in Figure 7-2 (i.e., [1] the Hanford Reach National Monument and Gable Mountain, and [2] the entire Hanford site). The assumption is that the time spent hunting, gathering, and fishing is negligible relative to the time spent at the offsite location, hence, there is no exposure time or exposure frequency associated with those particular locations. Furthermore, it is also assumed that adults and children spend 1 hour/day in a sweat lodge at the applicable exposure locations (offsite), but that the water used for the sweat lodge is from the Columbia River maximum as described above. Table 7-1 should be consulted for a summary of pathways and associated exposure locations.

This approach is conservative because it includes the points of maximum concentration, expected to be located east of the 200 East Area, as well as the areas west and north of the 200 East Area where actual hunting, gathering, and fishing activities currently occur.

Exposure of the resident subsistence American Indian is considered a plausible scenario since (1) residents are present outside the site boundary and development could occur within the offsite location, and (2) American Indian people are presently allowed to access the Hanford site; however, this access is limited to individuals with security badges, and then only for limited purposes, such as religious purposes or to gather foods (approximately once per year) for ceremonies.

Current Exposure Timeframe

The resident subsistence American Indian is assumed to have a lifetime (70-year) exposure duration. Since the time of maximum potential soil concentration occurs at plant shut down after 40 years of deposition, it is assumed that for a plant operating from year 0 to 40, the resident subsistence American Indian is exposed throughout the period of plant operation and subsequent to plant shutdown (years 0 to 70). However, the resident subsistence American Indian child, who has a 6-year exposure duration, is assumed to be exposed from years 34 to 40 in the current scenario (child and adult are not necessarily the same individual).

Future Exposure Timeframe

Since the resident subsistence American Indian is assumed to have a 70-year exposure duration, the future resident subsistence American Indian is assumed to be exposed from years 40 to 110. The resident subsistence American Indian child, who has a 6-year exposure duration, is assumed to be exposed from years 40 to 46 in the future scenario (child and adult are not necessarily the same individual).

The resident subsistence American Indian (adult and child) exposure time (hours per day) and frequency (days per year) are the same as the current exposure scenario.

Alternate Resident Subsistence American Indian, Scenario #1

There are two alternate resident subsistence American Indian scenarios are included in this SLRA that are not necessarily endorsed by the DOE-ORP. These receptor scenarios were developed to more closely represent the lifestyle described by guidance documents issued by local tribes. The lifestyle and exposure

parameters of the first alternate resident subsistence American Indian are primarily based on data from *Exposure Scenario for CTUIR Traditional Subsistence Lifeways* (Harris and Harper 2004) and *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments* (Harris 2008). Other parameters were taken from the "A Native American Exposure Scenario" (Harris and Harper 1997) or from the EFH. Children's exposure parameters were developed by proportioning the child caloric intake reported in the CSEFH according to the various proportions of meat, vegetable, roots, etc. in the diet of the adult tribal member as reported in the guidance documents provided by the CTUIR. In order to assess the potential for exposure to a tribal member whose lifestyle differs from the resident subsistence American Indian described above, the uncertainty assessment of the PRA will include evaluation of the alternate resident subsistence American Indian exposure scenario described below.

The alternate resident subsistence American Indian #1 is assumed to live a traditional subsistence lifestyle, based on a seasonal hunting, plant gathering, and fishing. This receptor is assumed to live, work, and play at a single location (i.e., assumed to be at home 24 hours per day, 353 days per year), but spends one day a month away from home participating in ceremonial activities (assumed to occur at Gable Mountain[2]). It is assumed that the resident's home is located within the offsite grid. The alternate resident subsistence American Indian #1 (adult and child) is assumed to be exposed through inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water, and ingestion of wild plants, game (including game organs), wild fowl and fish (including fish organs). The consumption of livestock, dairy products, and domestic produce does not occur in this scenario. The alternate resident subsistence American Indian #1 is assumed to obtain fish, drinking water and water for sweat lodge activities from the point of maximum concentration in the Columbia River. No credit is given for soil and air exposures away from home (e.g., while hunting, gathering, fishing, or for ceremonial and cultural activities outside of the assessment area), except for the time spent at ceremonial activities at Gable Mountain. The exposure timing of this scenario is the same as the resident subsistence American Indian scenario described above; adult exposures in the current timeframe are assessed over a 70-year duration that spans the 40 year operational period of WTP and 30 years following its shutdown. Child exposures are assessed through age 6. Future timeframe exposures are assumed to occur immediately after plant shutdown.

Alternate Resident Subsistence American Indian, Scenario #2

The alternate resident subsistence American Indian #2 refers to the second of two tribal lifestyles modeled in this exposure assessment that is not necessarily endorsed by the DOE-ORP. The lifestyle and exposure parameters of the second alternate resident subsistence American Indian are primarily based on data from *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* (RUDOLFI Inc. 2007). Other parameters were taken from the EFH. Children's exposure parameters were developed by proportioning the child caloric intake reported in the CSEFH according to the various proportions of meat, vegetable, roots, etc., in the diet of the adult tribal member as reported in the guidance documents provided by the Yakama Nation. In order to assess the potential for exposure to a resident subsistence American Indian whose lifestyle differs from the resident subsistence American Indian receptor described above, the uncertainty assessment of the PRA will include evaluation of the alternate resident subsistence American Indian exposure scenario described below.

[2] The actual location of tribal ceremonial activities varies with the nature of the activity, and is considered confidential. Gable Mountain is chosen as the location for ceremonial activities in the WTP risk assessment because it is a place of significance and is in close proximity to WTP, making related exposures at this location conservative and bounding.

The alternate resident subsistence American Indian #2 is assumed to live a traditional subsistence lifestyle, based on consumption of homegrown produce and livestock, in addition to seasonal hunting, plant gathering, and fishing. This receptor is assumed to live, work, and play at a single location continuously (i.e., the resident subsistence American Indian is assumed to be at home 24 hours per day, 365 days per year). It is assumed that the resident's home is located within the offsite grid. The alternate resident subsistence American Indian #2 (adult and child) is assumed to be exposed through inhalation of emissions, ingestion of soil, inhalation of resuspended soil, ingestion of drinking water. This receptor's diet includes domestic produce and livestock, supplemented with wild produce, game, and fish. To fully bound the estimated risk, it is assumed that all domestic produce and livestock is homegrown, and that all wild produce and game is taken from the hunter/gatherer area. The alternate resident subsistence American Indian #2 is assumed to obtain fish, drinking water and water for sweat lodge activities from the point of maximum concentration in the Columbia River. No credit is given for soil and air exposures away from home (e.g., while hunting, gathering, fishing, or for ceremonial and cultural activities away from home). The exposure timing of this scenario is the same as the resident subsistence American Indian scenario described above; adult exposures in the current timeframe are assessed over a 70 year duration that spans the 40 year operational period of WTP and 30 years following its shutdown. Child exposures are assessed through age 6. Future timeframe exposures are assumed to occur immediately after plant shutdown.

7.1.3.10 Nursing Infant of Resident Subsistence American Indian

General Description

The nursing infant of the subsistence tribal resident is the infant of the adult resident subsistence American Indian described above.

Exposure Pathways

The nursing infant of the resident subsistence American Indian is assumed to be exposed to PCDDs/PCDFs, coplanar PCBs, and four ROPCs through ingestion of breast milk from the adult resident subsistence American Indian exposed through inhalation of emissions; ingestion of soil; inhalation of resuspended soil; ingestion of drinking water; and ingestion of traditional foods. It is assumed that the mother does not participate in sweat lodge activities during the lactation period, and is therefore not exposed to pathways associated with the sweat lodge.

Exposure Location

The nursing infant of the resident subsistence American Indian is assumed to reside with the resident subsistence American Indian described above within the Hanford offsite location. The current and future exposure of a nursing infant of the resident subsistence American Indian within the Hanford offsite grid is considered a plausible scenario because residents are present outside the Hanford site boundary and development could occur at the offsite maximum point or points within the next 40 years.

7.1.3.11 Acute Exposure

The EPA (2005a) recommends evaluating potential acute exposures in addition to the chronic exposures evaluated by previously described exposure scenarios. The acute exposure scenario includes direct inhalation of airborne COPC and ROPC emissions and exposure to external radiation from airborne ROPC emissions at the estimated maximum one-hour concentration. The receptor for the acute exposure scenario is located at the point of maximum one-hour concentration and is independent of land use.

Because the acute exposure scenario is based on the maximum-modeled concentration and assumes that a receptor will be present at the location of that maximum during the hour in which it occurs, this is considered a worst-case scenario. However, it may also represent a plausible location for the receptor.

This acute scenario is designed to evaluate the worst-case air concentration resulting from normal emissions combined with short-term meteorological conditions that result in higher than normal air concentrations. Acute emissions estimates include process upset and cell emissions in addition to normal stack emissions as described in Section 5. The acute scenario is not an accident (e.g., fire, explosion) scenario. Accident scenarios are evaluated in separate documents to support nuclear licensing requirements.

Because the WTP facilities do not handle waste outside the buildings (all waste management activities are conducted inside the negative pressure cells, in sealed transport containers, or doubly contained pipelines) and do not release uncontrolled emissions except through building ventilation systems, there are no "fugitive" emissions. The building cell ventilation systems are equipped only with HEPA filters to control particulate and do not control vapors. Within WTP, the process upset and cell emissions are those vapor emissions that leak from valve, connectors, etc. within the facility that are incidental to waste processing and considered uncontrolled, with the exception of HEPA filtration control of the particulate phase.

7.1.4 Exposure Pathways

Exposure pathways to be evaluated for each of these exposure scenarios are summarized in Table 7-1 and the conceptual exposure model (Figure 7-4). Both direct exposure to emissions and indirect exposure to other media (such as soil and food) contaminated by emissions will be evaluated. The following are direct exposure pathways to be included in the quantitative risk assessment:

- COPCs and ROPCs
  - Direct inhalation of emissions
- ROPCs only
  - External exposure to radionuclides in air

Indirect exposure pathways to be included in the quantitative risk assessment are as follows:

- COPCs and ROPCs
  - Ingestion of soil
  - Inhalation of resuspended soil
  - Ingestion of homegrown or wild gathered produce
  - Ingestion of homegrown beef, milk, chicken, eggs, and pork
  - Ingestion of wild game, wildfowl, and wildfowl eggs
  - Ingestion of drinking water
  - Ingestion of fish
  - Inhalation of vapors and suspended particulates in sweat lodge
  - Dermal absorption in the sweat lodge
- ROPCs only

  - External exposure to radionuclides in soil
- PCDDs/PCDFs, PCBs, and selected ROPCs (Sr-90, I-129, Cs-134, and Cs-137) only
  - Ingestion of breast milk

External radiation exposure will be quantitatively evaluated for radionuclides in air and soil. External radiation exposure is not expected to be significant for surface water because of the following:

- Distance from the WTP to the Columbia River will result in extremely low concentrations of ROPCs through deposition.
- ROPC concentrations in air near the WTP and in soil following deposition and accumulation will far exceed surface water concentrations.
- Exposure to air and soil is continuous, while potential exposure to surface water is intermittent.

Therefore, external radiation exposure will not be evaluated for surface water because the distance from the WTP to the Columbia River will result in extremely low concentrations of ROPCs through deposition compared with other media.

The EPA (2005a) has identified the following three exposure pathways, generally considered insignificant contributors to risk at thermal treatment facilities:

- Groundwater pathways
- Resuspended dust
- Dermal contact

Groundwater pathways are generally not significant contributors to risk from airborne emissions because exposure concentrations in groundwater following air dispersion, deposition, leaching, and groundwater dispersion are much less than concentrations in air, soil, and other media. Conditions at the Hanford site (i.e., low precipitation) will make the contribution to groundwater even less than at other sites. Therefore, exposure to groundwater will not be included in the quantitative risk assessment. However, surface water concentrations will be used to evaluate the ingestion of drinking water, as well as inhalation and dermal absorption from exposure in a sweat lodge.

Inhalation of resuspended dust can be an important exposure pathway at contaminated sites where the contaminant source is at the surface or in the soil, as explained in the air-dispersion modeling portion (Section 6) of this work plan. At these sites, dust resuspension generally represents the only source of inhalation exposure (unless significant volatiles are present). At sites such as the WTP where the source of COPCs and ROPCs is airborne emissions, direct, continuous inhalation of these emissions is a much more important exposure pathway than periodic inhalation of fugitive dust. Although it is generally considered insignificant at most sites, inhalation of resuspended dust will be included in the SLRA (CCN 064332) because of the dry, dusty conditions at the Hanford site.

Dermal exposure pathways (to soil, surface water, or air) will not be included in the SLRA, with the exception of exposures from participation in sweat lodge activities. This is a non-conservative assumption (i.e., it will underestimate exposure to contaminants in soil, surface water, and air) because dermal contact will occur. However, dermal exposure pathways have been identified as insignificant contributors to risk in numerous risk assessments prepared or reviewed, or both, by EPA for airborne

emissions from thermal treatment facilities (i.e., the amount that exposure is underestimated due to excluding this pathway is insignificant). If initial PRA results indicate that the soil ingestion pathway results in risks that are borderline for any plausible receptor, then the dermal exposure pathway may be included in the PRA. A discussion of the potential impact associated with exclusion of this minor pathway from the quantitative risk assessment will be included in the uncertainty assessment of the PRA.

7.1.5 Quantification of Exposure

The following subsections provide the equations that will be used to quantify intake (or dose) for each COPC and ROPC. The equations used to quantify exposures to COPCs and ROPCs differ slightly. Estimates of COPC intake will be quantified as the lifetime average daily dose (*LADD*) and average daily dose (*ADD*) in units of mg/kg·day. The *LADD* defines a dose level that is distributed (averaged) over an entire lifetime. Unlike the *LADD*, the *ADD* is averaged over a specific incremental exposure period rather than an entire lifetime. Estimates of ROPC intake will be quantified as a total intake in units of picocuries (pCi) over the entire exposure duration. This is explained in greater detail below.

The EPCs for COPCs have units of mass per mass of media (mg/kg for soil, sediment, and food) and mass per volume of media (mg/L for surface water and $\mu g/m^3$ for air). The corresponding daily intake (or dose) units for COPCs are in mass per mass per time (mg/kg·day), that is, the mass concentration of the exposure media per unit time. The EPCs for ROPCs have units of activity per mass of media (pCi/g for soil and food) and activity per volume of media (pCi/L for surface water and pCi/m^3 for air). The corresponding intake (or dose) units for ROPCs are activity (pCi), that is, total radioactivity received over the entire exposure period. This is because the dose due to uptake of a COPC is averaged over the exposure period while the dose from ROPC exposure is cumulative. Accordingly, cancer slope factors for COPCs are in units of time per mass concentration (day·kg/mg), reference doses for COPCs are in units of mass concentration per unit time (mg/kg·day), while slope factors for ROPCs are in units of per radioactivity (pCi^{-1}).

The intake equations presented in the HHRAP (EPA 2005a) are for use with COPCs and reflect the exposure concentration (*EC*) or daily intake (*I*) for COPCs for an assumed exposure time of 24 hours/day. However, for the exposure scenarios considered in this risk assessment, the exposure time (the amount of time each day that a receptor is exposed), as well as exposure frequency (number of exposure events in days per year), and the exposure duration (the number of years of exposure) vary as a function of receptor lifestyle. The HHRAP does not provide equations for periodic exposures due to varied exposure times, however, RAGS Part F (EPA 2009) states that exposures can be weighted by the fraction of the total exposure time that each period represents. That is, the exposure (*EC*) can be weighted according to the ratio of the exposure time over the averaging time. Accordingly, daily intake of COPCs are corrected for receptor exposure time by multiplying the daily intake (as computed in accordance with the HHRAP) by the receptor exposure time (*ET*) (described in subsequent sections of this work plan) as shown in the equations for intake. In addition, since risk is to be estimated by applying the reference dose or cancer slope factor, the following equations are used to convert daily COPC intake into a *LADD* and *ADD* in units of mg/kg·day. The equations below are based on the equations that appear in HHRAP Tables C-1-7 and C-1-8, and in RAGS Part F Equation 6:

for carcinogenic COPCs and ROPCs:

$$LADD_i = I_i \cdot \frac{ED_i \cdot EF_i}{AT_C \cdot CF} \text{ and } EC_i = C_a \cdot \frac{ET_i \cdot EF_i \cdot ED_i}{AT_C \cdot CF}$$

for non-carcinogenic COPCs:

$$ADD_i = I_i \cdot \frac{ED_i \cdot EF_i}{AT_N \cdot CF} \text{ and } EC_i = C_a \cdot \frac{ET_i \cdot EF_i \cdot ED_i}{AT_N \cdot CF}$$

where:

ADD_i = average daily dose due to exposure pathway *i* for the receptor's total exposure period (mg/kg·day)

$LADD_i$ = lifetime average daily dose due to exposure pathway *i* for the receptor's total exposure period (mg/kg·day or pCi)

EC_i = exposure concentration due to exposure pathway *i* ($\mu g/m^3$ or pCi/m^3)

I_i = daily intake due to exposure pathway *i* (mg/kg·day or pCi)

C_a = contaminant concentration in air ($\mu g/m^3$ or pCi/m^3)

ED_i = exposure duration at the location where the receptor is exposed to pathway *i* (number of years that the receptor is exposed to the COPC or ROPC)

EF_i = exposure frequency at the location where the receptor is exposed to pathway *i* (number of days per year that the receptor is exposed to the COPC or ROPC)

ET_i = exposure time at the location where the receptor is exposed to pathway *i* (number of hours per day that the receptor is exposed to the COPC or ROPC)

AT_N = averaging time for noncarcinogens, typically the same as the receptor's exposure duration (yr)

AT_C = averaging time for carcinogens, typically the lifetime of the receptor (yr)

CF = conversion factor of 365 day/yr for $LADD_i$ and ADD_i, and 8760 hr/yr for EC_i

Cumulative *ADD*s and *LADD*s for each constituent can be computed by summing the *ADD* and *LADD* for a COPC from each applicable pathway.

The equations that will be used to quantify intake or exposure due to each of the exposure pathways are based on those presented in Appendix C of EPA 2005a. The EPCs of each exposure medium (such as air and soil) will be calculated as described in Sections 6.1.4 and 7.1.7 of this RAWP. Receptor-specific exposure parameters (such as exposure frequency and duration) are summarized in the tables listed below:

Receptors	Exposure Parameters
Hanford Site Industrial Worker	Table 7-2
Resident	Table 7-3
Resident Subsistence Farmer	Table 7-4
Resident Subsistence Fisher	Table 7-5
Resident Subsistence American Indians	Table 7-6, Table 7-7 and Table 7-8

The equations provided in the following subsections, along with the source of the EPCs and exposure parameters that will be used in these equations, are summarized below:

Exposure Medium and Pathway	Equation	Source of Exposure Point Concentrations	Applicable Receptor
Air (Section 7.1.5.1)			
Inhalation of emissions	modified HHRAP Table C-2-1	Section 6.1	All
External exposure to ROPCs in air	modified Eq. 5 from EPA 2000	Section 6.1	All
Soil (Section 7.1.5.2)			
Incidental ingestion	HHRAP Table C-1-1 and modified Eq. 1 from EPA 2000	Section 6.2	All
Inhalation of resuspended dust	modified HHRAP Table C-2-1 and modified Eq. 3 from EPA 2000	Section 6.2	All
External exposure to ROPCs in soil	modified Eq. 5 from EPA 2000	Section 6.2	All
Foodstuffs (Section 7.1.5.3)			
Ingestion of domestic and wild produce	HHRAP Table C-1-2	Section 6.5	All
Ingestion of domestic livestock and/or wild game	HHRAP Table C-1-3	Section 7.1.7.4	Farmer American Indian
Ingestion of fish	HHRAP Table C-1-4	Section 7.1.7.5	Fisher American Indian
Surface Water (Section 7.1.5.4)			
Drinking water ingestion	HHRAP Table C-1-5	Section 6.3	All
Sweat Lodge (Section 7.1.5.5)			
Inhalation in sweat lodge	modified Eqs. 7 and 15 in Appendix 4 of Harris and Harper (2004)	Section 6.3	American Indian
Dermal exposure in sweat lodge	modified Eq. 18 in Appendix 4 of Harris and Harper (2004)	Section 6.3	American Indian

7.1.5.1 Direct Exposure to Air

Direct exposure to air includes inhalation of vapor and particulate emissions and external exposure to ionizing radiation in air.

Direct Inhalation

A modified version of the equation in Table C-2-1 of the HHRAP will be used to calculate the inhalation of vapor phase and particulate emissions. The equation is modified by the introduction of the exposure time in accordance with RAGS Part F guidance (Equation 6) for periodic or microenvironment exposures (the HHRAP equation for exposure concentration from direct inhalation assumes a 24 hr/day exposure time).

$$EC_{inh} = \frac{C_a \cdot ET \cdot EF \cdot ED}{AT \cdot CF} \qquad \text{(modified HHRAP Table C-2-1)}$$

where:

EC_{inh} = exposure concentration of COPCs or ROPCs through inhalation of emissions (mg/m^3 or pCi/m^3)
C_a = concentration of COPC or ROPC in air (µg/m^3 or pCi/m^3) calculated as described in Section 6.1
ET = exposure time (hr/day)
EF = exposure frequency (day/yr)
ED = exposure duration (yr)
AT = averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) (yr)
CF = units conversion factor of $365\frac{\text{day}}{\text{yr}} \cdot 24\frac{\text{hr}}{\text{day}}$

For ROPCs, inhalation slope factors take into account the age- and gender-dependence of radionuclide intake, metabolism, dosimetry, radiogenic risk, and competing causes of death in estimating the cancer risk from low-level exposures to radionuclides in the environment (EPA 2001). Accordingly, the exposure concentration from ROPCs is converted to intake based on the inhalation rate and averaging time of the exposure. For ROPCs the total exposure from inhalation of air is:

ROPCs: $I_{inh} = EC_{inh} \cdot IR \cdot AT \cdot CF$ (modified HHRAP Table C-3-1)

where:

I_{inh} = intake of ROPC via inhalation (pCi)
EC_{inh} = exposure concentration of ROPCs through inhalation of emissions (pCi/m^3)
IR = inhalation rate (m^3/hr)
AT = averaging time for carcinogens (AT_C) (yr)
CF = units conversion factor of 8760 (hr/yr)

External Exposure in Air

A modified version of Equation 5 from *Soil Screening Guidance for Radionuclides: Technical Background Document* (EPA 2000) will be used to calculate the external exposure to ionizing radiation in

air from ROPCs. The equation has been modified by substituting air concentration for soil screening level and dividing by the slope factor to derive a dose.

ROPCs: $I_{ira} = C_a \cdot EF \cdot ED \cdot ACF \cdot \left[ET_o + \left(ET_i \cdot S_e\right)\right] \cdot CF$ (modified Eq. 5 from EPA 2000)

where:

- I_{ira} = external exposure to radiation from ROPCs in air (Bq-sec/m^3)
- C_a = average air concentration of ROPC (pCi/m^3) calculated as described in Section 6.1
- EF = exposure frequency (day/yr)
- ED = exposure duration (yr)
- ACF = area correction factor for an infinite slab, 1.0 (unitless)
- ET_o = exposure time fraction outdoors (unitless); receptor-specific ET_o values are described below
- ET_i = exposure time fraction indoors (unitless); receptor-specific ET_i values are described below
- S_e = shielding factor (unitless); S_e is described below
- CF = units conversion factor of $0.37 \frac{\text{Bq}}{\text{pCi}} \cdot 86400 \frac{\text{sec}}{\text{day}}$

The exposure time fraction outdoors (ET_o) represents the fraction of the day that the receptor is at the exposure location and outdoors while the fraction indoors (ET_i) represents the fraction of the day that the receptor is at the exposure location and indoors.

For the resident scenario, it is assumed that adults spend 94 % of their time indoors and 6 % outdoors (EPA 1997a) while children spend 77 % of their time indoors and 23 % outdoors. The median percent of time spent outdoors on a farm (adults and children) is reported as 12 %, and the 90th percentile is reported as 42 % (EPA 1997a). For the resident subsistence farmer and subsistence fisher scenarios, receptors (both adults and children) are assumed to spend 42 % of their time outdoors and 58 % indoors (approximately an additional 8 hours outdoors each day). For the resident subsistence American Indian, the time spent outdoors is based on values provided in the TC&WM EIS (i.e., 66 % indoors, 12 % outdoors for both adults and children). The resident subsistence American Indian also spends 2 hours/day (8 %) in a sweat lodge and another 14 % of time at an undisclosed location. External air exposure is not assessed at these locations because they are presumed to be locations where ionizing radiation is not an issue. Adults and children in the alternate tribal scenarios are assumed to spend 50 % of their time outdoors and 50 % indoors (alternate scenario #1, based on Harper 1997), 29 % of their time outdoors and 71 % of their time indoors (alternate scenario #2, based on RUDOLFI Inc. 2007).

For the Hanford site industrial worker scenario, it is assumed that work is performed both outdoors and indoors; therefore, workers spend 50 % of their work day indoors and 50 % outdoors. Outdoor occupancy patterns of the worker after work are assumed to be the same number of hours as the resident (6 % of the 24-hour day outdoors - that is, 1.44 hours/day), leaving the remaining hours of the day for indoor activities (equating to 61 % of the 24-hour day). During the weekend and other non-work days, the worker's outdoor/indoor occupancy fraction is assumed to be the same as the resident's.

A shielding factor of 0.4 is used (EPA 2000) to account for shielding while the receptor is indoors. No shielding is assumed while the receptor is outdoors, as the gamma radiation originating in soil is not impeded by a solid obstacle prior to intercepting the receptor.

7.1.5.2 Exposure to Soil

Exposure to soil includes ingestion of soil, inhalation of resuspended soil, and external exposure to ROPCs in soil.

Ingestion of Soil

Table C-1-1 of the HHRAP will be used to calculate the average soil concentration over exposure duration for COPCs. The equation is modified with the use of the exposure time parameter. Use of this parameter is necessary since the exposure time of receptors varies for the scenarios considered in the risk assessment. A modified version of Equation 1 from *Soil Screening Guidance for Radionuclides: Technical Background Document* (EPA 2000) will be used to calculate the ingestion of soil for ROPCs. The ROPC equation from EPA (2000) has been modified by substituting soil concentration for soil screening level and dividing by the slope factor to derive an intake.

$$\text{COPCs: } I_{soil} = \frac{Cs \cdot ET \cdot CR_{soil} \cdot F_i}{BW \cdot CF_1} \qquad \text{(HHRAP Table C-1-1)}$$

$$\text{ROPCs: } I_{soil} = Cs \cdot CR_{soil} \cdot F_i \cdot ET \cdot EF \cdot ED \cdot CF_2 \qquad \text{(modified Eq. 1 from EPA 2000)}$$

where:

I_{soil} = intake of COPC or ROPC due to soil ingestion (mg/kg·day or pCi)
Cs = concentration of COPC or ROPC in soil (mg/kg or pCi/g) calculated per Section 6.2
CR_{soil} = consumption rate of soil (kg/day)
F_i = fraction of ingested soil that is contaminated (unitless)
ET = exposure time (hr/day)
EF = exposure frequency (day/yr)
ED = exposure duration (yr)
BW = body weight (kg)
CF_1 = units conversion factor of $24\frac{\text{hr}}{\text{day}}$
CF_2 = units conversion factor of 1000 (g/kg)

Inhalation of Resuspended Soil

A modified version of Equation 3 from *Soil Screening Guidance for Radionuclides: Technical Background Document* (EPA 2000) will be used to calculate exposure resulting from inhalation of resuspended soil using the particulate emission factor (*PEF*) approach from the EPA soil screening guidance (EPA 2000). The equation has been modified by substituting soil concentration for soil screening level and dividing by the slope factor to derive a dose. To derive the intake of COPCs and ROPCs from soil inhalation, the equation for exposure concentration (HHRAP Table C-2-1), is modified

by substituting the soil concentration divided by the *PEF* for the air concentration. The equation is further modified by the introduction of the exposure time in accordance with RAGS Part F guidance for periodic or microenvironment exposures. Terms for these exposure parameters are applied using the equations for hazard index (HHRAP Table C-1-7) and cancer risk (HHRAP Table C-1-8).

COPCs: $$EC_{soil} = \frac{\left(\frac{Cs}{PEF}\right) \cdot ET \cdot EF \cdot ED}{AT \cdot CF_1}$$ (modified HHRAP Table C-2-1)

ROPCs: $$EC_{soil} = \frac{\left(\frac{Cs}{PEF}\right) \cdot ET \cdot EF \cdot ED \cdot CF_2}{AT \cdot CF_1}$$ (modified HHRAP Table C-2-1)

where:

EC_{soil} = intake of COPC or ROPC through inhalation of resuspended soil (mg/m^3 or pCi/m^3)
Cs = soil concentration of COPC or ROPC (mg/kg or pCi/g) calculated per Section 6.2
PEF = particulate emission factor (m^3/kg); *PEF* is described below
IR = inhalation rate (m^3/hr)
ET = exposure time (hr/day)
EF = exposure frequency (day/yr)
ED = exposure duration (yr)
BW = body weight (kg)
CF_1 = units conversion factor of $24 \frac{\text{hr}}{\text{day}}$
CF_2 = units conversion factor of 1000 (g/kg)

The *PEF* relates the concentration of contaminant in soil with the concentration of dust particles in the air. The presence of vegetation, gravel, pavement, or other cover will prevent the generation of fugitive dust. EPA default *PEF* values assume 50 % vegetative cover and 50 % open soil. The EPA provides site-specific dispersion modeling and meteorological factors for 29 cities in the United States and recommends developing a site-specific *PEF* by identifying the climatic zone for the site (Figure A-1, EPA 2000) followed by selecting modeling parameters corresponding to the site's climatic zone and size. The Hanford site is located in Climatic Zone 4, so a value of 40.4 is used to describe the inverse mean concentration at center of a 30-acre-square source (average value of climatic zone 4 cities). An average wind speed of 3.23 m/s (average value from Hanford Meteorological Station measurements) and a particle size mode of 262 µm have been chosen to represent site conditions (refer to Appendix A). Using methodologies found in Streile et al. (1996) and Cowherd et al. (1985), the *PEF* is conservatively estimated at 7.06×10^7 m^3/kg. Refer to the discussion in Appendix A for additional details.

The intake of radionuclides due to inhalation of resuspended soil can be computed using the same conversion equations used to calculate the intake from air inhalation as previously discussed.

ROPCs: $$I_{inhsoil} = EC_{soil} \cdot IR \cdot AT \cdot CF$$ (modified HHRAP Table C-3-1)

where:

$I_{inhsoil}$ = intake of constituent via inhalation (pCi)
EC_{soil} = exposure concentration of COPCs or ROPCs through inhalation of emissions (pCi/m^3)
IR = inhalation rate (m^3/hr)
AT = averaging time for carcinogens (AT_C) (yr)
CF = units conversion factor of 8760 (hr/yr)

External Exposure to Soil

A modified version of Equation 5 from *Soil Screening Guidance for Radionuclides: Technical Background Document* (EPA 2000) will be used to calculate the external exposure to ionizing radiation in soil from ROPCs. The equation has been modified by substituting soil concentration for soil screening level and dividing by the slope factor to derive a dose.

$$\text{ROPCs: } I_{irs} = \frac{Cs \cdot EF \cdot ED \cdot ACF \cdot \left[ET_o + ET_i \cdot (1 - S_e)\right]}{CF} \qquad \text{(modified Eq. 5 from EPA 2000)}$$

where:

I_{irs} = external exposure to radiation from ROPCs in soil (pCi-yr/g)
Cs = soil concentration of ROPC (pCi/g) calculated per Section 6.2
ACF = area screening factor, 1.00
EF = exposure frequency (day/yr)
ED = exposure duration (yr)
ET_o = exposure time fraction outdoors (unitless); receptor-specific ET_o values are described below
ET_i = exposure time fraction indoors (unitless); receptor-specific ET_i values are described below
S_e = shielding factor (unitless); S_e is described below
CF = units conversion factor 365 (day/yr)

The exposure time fraction outdoors (ET_o) represents the fraction of the day that the receptor is at the exposure location and outdoors, while the fraction indoors (ET_i) represents the fraction of the day that the receptor is at the exposure location and indoors.

For the resident scenario, it is assumed that adults spend 94 % of their time indoors and 6 % outdoors (EPA 1997a) while children spend 77 % of their time indoors and 23 % outdoors. The median percent of time spent outdoors on a farm (adults and children) is reported as 12 %, and the 90th percentile is reported as 42 % (EPA 1997a). For the resident subsistence farmer and subsistence fisher scenarios, receptors (both adults and children) are assumed to spend 42 % of their time outdoors and 58 % indoors (approximately an additional 8 hours outdoors each day). For the resident subsistence American Indian, the time spent outdoors is based on values provided in the TC&WM EIS (i.e., 66 % indoors, 12 % outdoors for both adults and children). The resident subsistence American Indian also spends 2 hours/day (8 %) in a sweat lodge and another 14 % of time at an undisclosed location. External soil exposure is not assessed at these locations because they are presumed to be locations where soil contamination is not an

issue. Adults and children in the alternate American Indian scenarios are assumed to spend 50 % of their time outdoors (alternate scenario #1, based on Harper 1997) and 29 % of their time outdoors (alternate scenario #2, based on RUDOLFI Inc. 2007).

For the Hanford site industrial worker scenario, it is assumed that work is performed both outdoors and indoors; therefore, workers spend 50 % of their work day indoors and 50 % outdoors. Outdoor occupancy patterns of the worker after work are assumed to be the same as the resident (6 % of the 24-hour day outdoors - that is, 1.44 hours/day), leaving the remaining hours of the day for indoor activities (equating to 61 % of the 24-hour day). During the weekend and other non-work days, the worker's outdoor/indoor occupancy fraction is assumed to be the same as the resident's.

A shielding factor of 0.4 is used (EPA 2000) to account for shielding while the receptor is indoors. No shielding is assumed while the receptor is outdoors, as the gamma radiation originating in soil is not impeded by a solid obstacle prior to intercepting the receptor.

7.1.5.3 Exposure to Foodstuffs

Exposure to foodstuffs includes ingestion of domestic produce by the resident; ingestion of domestic produce, beef, pork, milk, chicken, and eggs by the resident subsistence farmer; ingestion of domestic produce and fish by the resident subsistence fisher; and ingestion of wild plants, wild game, wildfowl, wildfowl eggs, and fish by the resident subsistence American Indian and the alternate resident subsistence American Indian #1. The alternate tribal resident #2 consumes domestic foods and supplements his/her diet with wild foods.

Ingestion of Produce

Table C-1-2 of the HHRAP will be used to calculate the ingestion of COPCs in domestic produce and wild plants. A modified version of the equation in Table C-1-1 of the HHRAP will be used to calculate the ingestion of ROPCs in domestic produce and wild plants. The equation is modified by multiplying by the receptor body weight since the consumption rate is in terms of unit body weight.

COPCs: (HHRAP Table C-1-2)

$$I_{ag} = \left[(Pd + Pv + Pr_{ag}) \cdot CR_{ag} + Pr_{ag} \cdot CR_{pp} + Pr_{bg} \cdot CR_{bg} \right] \cdot F_{ag}$$

ROPCs: (modified HHRAP Table C-1-2)

$$I_{ag} = \left[(Pd + Pv + Pr_{ag}) \cdot CR_{ag} + Pr_{ag} \cdot CR_{pp} + Pr_{bg} \cdot CR_{bg} \right] \cdot F_{ag} \cdot EF \cdot ED \cdot BW \cdot CF$$

for carbon-14 and tritium:

$$I_{ag} = \left[C_V \cdot \left(CR_{ag} + CR_{pp} + CR_{bg} \right) \right] \cdot F_{ag} \cdot EF \cdot ED \cdot BW \cdot CF$$

where:

I_{ag} = intake of COPC or ROPC through ingestion of produce (mg/kg·day or pCi)

Pd = COPC or ROPC concentration in aboveground produce due to direct deposition onto plant surfaces (mg/kg or pCi/g) calculated per Section 6.6. Pd is zero in future exposure scenarios since they occur after cessation of emissions.

Pv = COPC or ROPC concentration in aboveground produce due to air-to-plant transfer (mg/kg or pCi/g) calculated per Section 6.6. Pv is zero in future exposure scenarios since they occur after cessation of emissions.

Pr_{ag} = COPC or ROPC concentration in aboveground produce due to root uptake (mg/kg or pCi/g) calculated per Section 6.6

Pr_{bg} = COPC or ROPC concentration in belowground produce due to root uptake (mg/kg or pCi/g) calculated per Section 6.6

C_V = plant concentration (carbon-14, $C_{V(C\text{-}14)}$, and tritium, $C_{V(H\text{-}3)}$) as discussed in Section 6.6.2 (pCi/g)

CR_{ag} = consumption rate of aboveground unprotected produce (kg/kg·day)

CR_{pp} = consumption rate of aboveground protected produce (kg/kg·day)

CR_{bg} = consumption rate of belowground produce (kg/kg·day)

F_{ag} = fraction of ingested produce that is contaminated (unitless)

EF = exposure frequency (day/yr)

ED = exposure duration (yr)

BW = body weight (kg)

CF = units conversion factor of 1000 (g/kg)

Consumption rates for produce (kg/kg·day) are found in Table 7-2, Table 7-3, Table 7-4, Table 7-5, Table 7-6, Table 7-7, and Table 7-8.

Ingestion of Animal Products

Table C-1-3 of the HHRAP will be used to calculate the ingestion of COPCs and ROPCs in homegrown beef, milk, pork, poultry, wildfowl, eggs, and wild game.

COPCs: $I_i = A_i \cdot CR_i \cdot F_i$ (HHRAP Table C-1-3)

ROPCs: $I_i = A_i \cdot CR_i \cdot F_i \cdot EF \cdot ED \cdot BW \cdot CF$ (modified HHRAP Table C-1-3)

where:

I_i = intake of COPC or ROPC from animal product i (such as I_{beef}, I_{milk}, I_{pork}, $I_{poultry}$, I_{eggs} for the subsistence farmer, and $I_{wild\ fowl}$, $I_{wild\ eggs}$, I_{game}, $I_{game\ organs}$ for the American Indian scenarios) (mg/kg·day or pCi)

A_i = concentration of COPC or ROPC in animal product i (mg/kg or pCi/g) calculated per Section 7.1.7.4

CR_i = consumption rate of animal product i (kg/kg·day); see Table 7-4, Table 7-6, Table 7-7, and Table 7-8 for values.

F_i = fraction of ingested animal tissue that is contaminated (unitless)

EF = exposure frequency (day/yr)

ED = exposure duration (yr)

BW = body weight (kg)

CF = units conversion factor of 1000 (g/kg)

Ingestion of Fish

A modified version of the equation in Table C-1-4 of the HHRAP will be used to calculate the ingestion of COPCs and ROPCs in fish. The modification is needed to account for consumption of fish organs by American Indian receptors.

COPCs: $I_{fish} = \left(C_{fish} \cdot CR_{fish} + C_{organs} \cdot CR_{organs}\right) \cdot F_{fish}$ (HHRAP Table C-1-4)

ROPCs: $I_{fish} = \left(C_{fish} \cdot CR_{fish} + C_{organs} \cdot CR_{organs}\right) \cdot F_{fish} \cdot EF \cdot ED \cdot BW \cdot CF$ (modified HHRAP Table C-1-4)

where:

I_{fish} = intake of COPC or ROPC from fish (mg/kg·day or pCi)
C_{fish} = concentration of COPC or ROPC in fish (mg/kg or pCi/g); C_{fish} will be calculated from surface water or sediment concentrations as applicable, calculated per Sections 6.3 and 6.4
CR_{fish} = consumption rate of fish fillets (kg/kg-body weight/day)
C_{organs} = concentration of COPC or ROPC in fish organs (mg/kg or pCi/g); C_{organs} will be calculated from surface water and sediment concentrations calculated per Sections 6.3 and 6.4
CR_{organs} = consumption rate of fish organs (kg/kg-body weight/day)
F_{fish} = fraction of ingested fish that is contaminated (unitless)
EF = exposure frequency (day/yr)
ED = exposure duration (yr)
BW = body weight (kg)
CF = units conversion factor of 1000 (g/kg)

Fish consumption rates are found in Table 7-5, Table 7-6, Table 7-7, and Table 7-8.

7.1.5.4 Exposure to Surface Water

Exposure to surface water includes the ingestion of surface water as drinking water and sweat lodge exposures through inhalation and dermal contact (Section 7.1.5.5).

Ingestion of Drinking Water

Table C-1-5 of the HHRAP will be used to calculate the ingestion of COPCs and ROPCs in drinking water.

COPCs: $I_{dw} = \frac{C_{dw} \cdot CR_{dw} \cdot F_{dw}}{BW}$ (HHRAP Table C-1-5)

ROPCs: $I_{dw} = C_{dw} \cdot CR_{dw} \cdot F_{dw} \cdot EF \cdot ED$ (modified HHRAP Table C-1-5)

where:

I_{dw} = intake of COPC or ROPC from drinking water (mg/kg·day or pCi)
C_{dw} = dissolved-phase COPC or ROPC water concentration (mg/L or pCi/L) calculated per Section 6.3
CR_{dw} = consumption rate of drinking water (L/day)
F_i = fraction of ingested drinking water that is contaminated (unitless)
EF = exposure frequency (day/yr)
ED = exposure duration (yr)
BW = body weight (kg)

Consumption rates for drinking water are found in Table 7-2, Table 7-3, Table 7-4, Table 7-5, Table 7-6, Table 7-7, and Table 7-8.

7.1.5.5 Sweat Lodge Exposures

Two exposure pathways will be evaluated for the sweat lodge: inhalation and dermal absorption.

Inhalation in Sweat Lodge

A modified version of Equation 7 in Appendix 4 of Harris and Harper (2004) will be used to calculate inhalation exposure for receptors inside the sweat lodge. The equation was modified to reflect the exposure concentration (*EC*) to be consistent with the HHRAP (the original equation was for intake, *I*). Volatile and semivolatile organic COPCs and volatile ROPCs (^{14}C, ^{3}H, and ^{129}I) may be released as vapors from water used in the sweat lodge.

$$EC_{sl} = \frac{C_{dw} \cdot \left(\frac{V_w}{2}\right) \cdot \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \cdot ET \cdot EF \cdot ED}{AT \cdot CF}$$

(modified Equation 7 in Appendix 4 of Harris and Harper [2004])

Due to the many uncertainties and the potential that aerosols may be generated by mechanical entrainment in addition to volatilization, nonvolatile inorganic COPCs and ROPCs are also evaluated for this pathway. In the sweat lodge environment, nonvolatile components become airborne as an aerosol as the water they were carried in vaporizes. Once airborne, nonvolatile compounds deposit onto solid surfaces with aqueous condensation, thus, the amount of contaminants available for inhalation is limited to that which is carried into the air phase by the volume of liquid water needed to create saturated conditions in the lodge. Harris and Harper (2004) present an equation for the intake of nonvolatile constituents utilizing the ideal gas law and the Antoine equation for the vapor pressure of water (Appendix 4, Equation 15). Modifying this equation for the exposure concentration yields the following:

$$EC_{sl} = \left(\frac{ET \cdot EF \cdot ED}{AT \cdot CF}\right) \cdot C_{dw} \cdot \left(\frac{MW_w}{R \cdot T_{sl} \cdot \rho_w}\right) \cdot e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)}$$

(modified Equation 15 in Appendix 4 of Harris and Harper [2004])

where:

EC_{sl} = exposure concentration of COPCs or ROPCs through inhalation in the sweat lodge (mg/m^3 or pCi/m^3)

C_{dw} = dissolved surface water concentration of COPCs and ROPCs (mg/L or pCi/L) calculated per Section 6.3

V_W = volume of water (4 L); see the discussion of V_W below

π = the constant *pi* (unitless); $\pi \approx 3.14159265359$

r = radius of sweat lodge (1 m)

MW_w = molar weight of water (18.01528 g/mol)

R = ideal gas constant (0.06237 $mmHg \cdot m^3/gmole \cdot K$)

T_{sl} = temperature of the sweat lodge (339 K)

ρ_w = density of liquid water at temperature T_{sl} (980.2 g/L)

ET = exposure time (hr/day)

EF = exposure frequency (day/yr)

ED = exposure duration (yr)

AT = averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) (yr)

e = base of the natural logarithm (unitless). $e = \sum_{i=0}^{\infty} \frac{1}{i!} \approx 2.718282$; the units for the Antoine equation, $e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)}$, are mmHg

CF = units conversion factor of 365 (day/yr)

Within the sweat lodge, water is splashed onto heated rocks to produce steam. It is assumed that a total of 4 L of water are used during a one-hour sweat lodge ceremony. For the HHRA, it is conservatively assumed that the entire concentration of volatile COPCs (all organics) and ROPCs (^3H, ^{14}C, and ^{129}I) in the 4 L of water may be volatilized and available for inhalation in the sweat lodge. It is possible that nonvolatile COPCs (inorganics) and ROPCs (all except ^3H, ^{14}C, and ^{129}I) may become airborne as an aerosol mist. The quantity of nonvolatile constituents that may be airborne is limited by the amount of water that may be in the air at any given time[3] (CCN 064329).

Note that the daily intake of radionuclides from inhalation in the sweat lodge is:

ROPCs: $I_{inh_{sl}} = EC_{sl} \cdot IR \cdot AT \cdot CF$ (modified HHRAP Table C-3-1)

where:

$I_{inh_{sl}}$ = intake of constituent via inhalation in the sweat lodge (pCi)

EC_{sl} = exposure concentration of ROPCs through inhalation in the sweat lodge (pCi/m^3)

[3] For nonvolatile constituents, the volume of liquid water needed to create a saturated vapor in the sweat lodge in units of liters (L) is $V_w = \left(\frac{p \cdot V_{sl}}{R \cdot T}\right)\left(\frac{MW_w}{\rho_w}\right)$ where V_{sl} is volume of air space in sweat lodge occupied by water vapor (2.094 m^3), and other variables are as defined above (refer to Harris and Harper [2004]).

IR = inhalation rate (m^3/hr)
AT = averaging time for carcinogens (AT_C) (yr)
CF = units conversion factor of 8760 (hr/yr)

Dermal Exposure in Sweat Lodge

Equation 18 in Harris and Harper (2004) will be used to calculate the dermal absorption of volatile and semivolatile compounds (e.g. $F_v \neq 0$) from water vapor in the sweat lodge.

$$\text{COPCs: } I_d = \frac{C_{dw} \cdot \left(\frac{V_w}{2}\right) \cdot \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \cdot SA \cdot Kp \cdot ET}{BW} \cdot CF$$

(Equation 18 in Appendix 4 of Harris and Harper [2004])

where:

I_d = intake of COPCs from adult dermal absorption within the sweat lodge (mg/kg·day)
C_{dw} = dissolved surface water concentration of COPCs (mg/L) calculated per Section 6.3
V_W = volume of water (4 L); see the discussion of V_W above
π = the constant *pi* (unitless); $\pi \approx 3.14159265359$
r = radius of sweat lodge (1 m)
SA = body surface area available for contact (m^2)
Kp = permeability constant (cm/hr); Kp is COPC-specific and provided in Supplement 4.
ET = exposure time (hr/day)
EF = exposure frequency (day/yr)
ED = exposure duration (yr)
BW = body weight (kg)
AT = averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) (yr)
CF = units conversion factor of 10^{-2} (m/cm)

Equations 19, 20, and 21 in Harris and Harper (2004) will be used to calculate the dermal absorption of nonvolatile compounds (e.g., $F_v = 0$) from water vapor in the sweat lodge. The intake includes the contribution from condensed (liquid) water ($I_{d,l}$) and vapor ($I_{d,v}$).

$$\text{COPCs: } I_{d,l} = \frac{C_{dw} \cdot SA \cdot Kp \cdot ET}{BW} \cdot CF$$

(Equations 19 and 20 in Appendix 4 of Harris and Harper [2004])

$$I_{d,v} = \left(\frac{SA \cdot Kp \cdot ET}{BW}\right) \cdot C_{dw} \cdot \left(\frac{MW_w}{R \cdot T_{sl} \cdot \rho_w}\right) \cdot e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)}$$

where:

$I_{d,l}$ = intake of COPCs from adult dermal absorption of condensate within the sweat lodge (mg/kg·day)

$I_{d,v}$ = intake of COPCs from adult dermal absorption of vapors within the sweat lodge (mg/kg·day)

I_d = intake of COPCs from adult dermal absorption of condensate and vapors within the sweat lodge (mg/kg·day)

C_{dw} = dissolved surface water concentration of COPCs (mg/L) calculated per Section 6.3

V_W = volume of water (4 L); see the discussion of V_W above

π = the constant *pi* (unitless); $\pi \approx 3.14159265359$

r = radius of sweat lodge (1 m)

SA = body surface area available for contact (m^2)

Kp = permeability constant (cm/hr); *Kp* is COPC-specific and provided in Supplement 4.

ET = exposure time (hr/day)

EF = exposure frequency (day/yr)

ED = exposure duration (yr)

BW = body weight (kg)

AT = averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) (yr)

MW_w = molar weight of water (18.01528 g/mol)

R = ideal gas constant (0.06237 mmHg·m^3/gmole·K)

T_{sl} = temperature of the sweat lodge (389 K)

ρ_w = density of liquid water at temperature T_{sl} (980.2 g/L)

CF = units conversion factor of $10\frac{\text{L}}{\text{m}^3 \cdot \text{cm}}$

e = base of the natural logarithm (unitless). $e = \sum_{i=0}^{\infty} \frac{1}{i!} \approx 2.718282$; the units for the Antoine equation, $e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)}$, are mmHg

and subsequently:

$$I_d = I_{d,l} + I_{d,v}$$

where:

I_d = intake of COPCs from adult dermal absorption within the sweat lodge (mg/kg·day)

$I_{d,l}$ = intake of COPCs from adult dermal absorption of condensate within the sweat lodge (mg/kg·day)

$I_{d,v}$ = intake of COPCs from adult dermal absorption of vapors within the sweat lodge (mg/kg·day)

Dermal absorption of inorganic COPCs and ROPCs is not included because this pathway is considered to be insignificant compared to inhalation for all inorganic COPCs and ROPCs except tritium (CCN 019247). Previously, the inhalation cancer slope factor (*CSF*) provided in the Health Effects Assessment Summary Tables (HEAST) [EPA 1997b] for tritium included a 50 % contribution from

dermal absorption. The new inhalation *CSF* for tritium provided in the updated the HEAST (EPA 2001) does not include the contribution from dermal absorption; therefore, dermal absorption of tritium from water vapor in the sweat lodge is evaluated separately. The internal dose from immersion in a plume of tritiated water vapor is approximately 50 % from inhalation and 50 % from dermal absorption (Till and Meyer 1983); therefore, the dose received from dermal absorption of tritium is accounted for by multiplying the inhalation dose for this ROPC by two.

7.1.5.6 Nursing Infant Exposure

Ingestion of Breast Milk

Table C-3-2 of the HHRAP will be used to calculate the *ADD* of COPCs and intake of ROPCs for an infant exposed to COPCs and ROPCs in breast milk. Infant exposure from breast milk is estimated assuming that the mother's breast milk has reached a steady state and that the contaminant in breast milk fat is the same as that in maternal body fat.

COPCs: $$ADD_{infant} = \frac{C_{milkfat} \cdot f_3 \cdot f_4 \cdot IR_{infant} \cdot ED_{infant}}{BW_{infant} \cdot AT_{infant}} \quad \text{(HHRAP Table C-3-2)}$$

ROPCs: $$ADD_{infant} = C_{milkfat} \cdot f_3 \cdot f_4 \cdot IR_{infant} \cdot ED_{infant} \cdot EF_{infant} \quad \text{(modified HHRAP Table C-3-2)}$$

where:

ADD_{infant} = average daily dose of COPCs or ROPCs from breast milk (pg/kg·day for chemicals or pCi for radionuclides)
$C_{milkfat}$ = concentration of COPC or ROPC in milk fat of breast milk for a specific exposure scenario of the mother, described below (pg/kg·day or pCi)
f_3 = fraction of breast milk that is fat (unitless)
f_4 = fraction of ingested COPC or ROPC that is absorbed (unitless)
IR_{infant} = infant ingestion rate of breast milk by infant (kg/day)
ED_{infant} = infant exposure duration (yr)
BW_{infant} = infant body weight of infant (kg)
AT_{infant} = infant averaging time (yr)
EF_{infant} = infant exposure frequency (days/yr)

The concentration in milk fat is estimated using Table C-3-1 of the HHRAP.

COPCs: $$C_{milkfat} = \frac{m \cdot h \cdot f_1}{0.693 \cdot f_2} \cdot CF \quad \text{(HHRAP Table C-3-1)}$$

ROPCs: $$C_{milkfat} = \frac{m \cdot h \cdot f_1}{BW_{mother} \cdot 0.693 \cdot f_2} \quad \text{(modified HHRAP Table C-3-1)}$$

where:

m = maternal intake of COPCs or ROPCs from all adult exposures (mg/kg·day for chemicals or pCi/day for radionuclides) calculated as:

Hanford site industrial worker[4] and resident:

$$m = I_{inh} + I_{soil} + I_{inhsoil} + I_{ag} + I_{dw}$$

resident subsistence farmer:

$$m = I_{inh} + I_{soil} + I_{inhsoil} + I_{ag} + I_{beef} + I_{milk} + I_{pork} + I_{domestic\ fowl} + I_{egg} + I_{dw}$$

resident subsistence fisher:

$$m = I_{inh} + I_{soil} + I_{inhsoil} + I_{ag} + I_{fish} + I_{dw}$$

resident subsistence American Indian[4]:

$$m = I_{inh} + I_{soil} + I_{inhsoil} + I_{ag} + I_{wild\ egg} + I_{game} + I_{fish} + I_{dw}$$

alternate resident subsistence American Indian #1[4]:

$$m = I_{inh} + I_{soil} + I_{inhsoil} + I_{ag} + I_{wild\ fowl} + I_{game} + I_{game\ organs} + I_{fish} + I_{fish\ organs} + I_{dw}$$

alternate resident subsistence American Indian #2[4]:

$$m = I_{inh} + I_{soil} + I_{inhsoil} + I_{ag} + I_{beef} + I_{milk} + I_{domestic\ fowl} + I_{wild\ fowl} + I_{game} + I_{fish} + I_{dw}$$

where the individual daily intake terms, I, will be calculated from equations above, with the exception of I_{inh} and $I_{inhsoil}$, which as discussed in further detail below.

h = biological half-life of COPC or effective half-life of ROPC (includes a radioactive decay component, see below) in the mother (days); h is COPC- and ROPC-specific and provided in Supplement 4

f_1 = fraction of ingested COPC or ROPC that is stored in fat (unitless)

f_2 = fraction of mother's weight that is fat (unitless)

BW_{mother} = body weight of mother (kg)

0.693 = natural logarithm of 2; the quantity $h/\ln(2)$ equates to $1/k_{elim}$, where k_{elim} is the elimination constant in the model that HHRAP Table C-3-1 was derived from (refer to EPA 1999a, Eq. 9-2)

CF = units conversion factor of 10^{-9} (pg/mg)

The equation above assumes that the contaminant concentration has reached steady state (hence, exposure duration and frequency, and averaging time of the mother are not incorporated), and that the concentration of contaminant is the same in milk fat as it is in maternal body fat.

The intake due to inhalation pathways, I_{inh} and $I_{inhsoil}$, is average daily COPC intake via inhalation (ADI) computed according to HHRAP Table C-3-1 (the variables I_{inh} and $I_{inhsoil}$ are used instead of ADI for consistency with the other intakes shown in this RAWP). Recalling the equation for exposure concentration shown in Sections 7.1.5.1 and 7.1.5.2, I_{inh} and $I_{inhsoil}$ can be computed using a modified version of HHRAP Table C-3-1:

[4] The Hanford site worker maternal exposure does not include exposure during retirement. Maternal exposure in tribal scenarios does not include sweat lodge exposures (presumably, mothers suspend sweat lodge participation during pregnancy and the subsequent the breast-feeding period).

$$I_{inh\ or\ inhsoil} = EC_{inh\ or\ inhsoil} \cdot \frac{IR}{BW_{mother}} \cdot CF$$

(HHRAP Table C-3-1 modified for exposure concentration)

where:

I_{inh} = intake of COPCs via inhalation of emissions (mg/kg·day)

$I_{inhsoil}$ = intake of COPCs via inhalation of resuspended soil (mg/kg·day)

EC_{inh} = exposure concentration of COPCs through inhalation of emissions (mg/m^3)

$EC_{inhsoil}$ = exposure concentration of COPCs through inhalation of resuspended soil (mg/m^3)

IR = inhalation rate of mother (m^3/hr)

BW_{mother} = body weight of mother (kg)

CF = units conversion factor of $24 \frac{hr}{day}$

For ROPCs, equations for I_{inh} and $I_{inhsoil}$ are presented in Sections 7.1.5.1 and 7.1.5.2, respectively.

The effective half-life for ROPCs includes a component for biological half-life, and a component for loss due to radioactive decay (isotope nuclear half-life).

ROPCs: $$h = \frac{h_b \cdot h_r}{h_b + h_r}$$ (Equation 7-1)

where:

h = effective half-life of ROPC

h_b = biological half-life of ROPC

h_r = radiological half-life of ROPC

Using this equation, the effective half-lives for the radionuclides of interest are given below:

ROPC	Biological Half-life (days)	Radiological Half-life (days)	Effective Half-life (days)
Cesium-134	1.14×10^2	7.67×10^2	9.92×10
Cesium-137	1.35×10^2	1.10×10^4	1.33×10^2
Iodine-129	1.38×10^2	5.84×10^9	1.38×10^2
Strontium-90	2.91×10^2	1.05×10^4	2.28×10^3

7.1.6 Exposure Parameters

The equations presented above are the basis for quantifying the exposure to COPCs and ROPCs experienced by a potential receptor. The values that will be used for each parameter identified in the equations are provided in Table 7-2 through Table 7-8 and described below. These parameters are

conservative to ensure that the exposures calculated in the SLRA overestimate, rather than underestimate, risk.

7.1.6.1 Hanford Site Industrial Worker

For the Hanford site industrial worker scenario, exposure values are presented in Table 7-2.

The Hanford site industrial worker is assumed to work both indoors (4 hours per day) and outdoors (4 hours per day) and to consume 200 mg soil per work-day rather than the default 50 mg per day because of this outdoor activity.

The Hanford site industrial worker is assumed to live within the offsite receptor exposure grid in addition to working at the onsite ground maximum. Exposure assumptions for the time spent at home are the same as those for a resident (Section 7.1.6.2) corrected for time spent at work. For example:

- This receptor is assumed to spend 8 hours per day at work and 16 hours per day at home for the 250 days per year he or she is also at work, and 24 hours per day at home for the 100 days per year he or she is not at work. The receptor is assumed to spend 24 hours per day at home, 350 days per year, during retirement. The remaining 15 days of the year are spent on vacation, at a location presumably beyond the assessment area.
- This receptor consumes a total of 2 L to 3 L per day of drinking water from the Columbia River maximum (i.e., on workdays the receptor consumes 2 L at work and 1 L at home, on nonwork days the receptor consumes 2 L at home).
- This receptor is assumed to spend 20 years working at the onsite ground maximum and living within the Hanford offsite grid, and another 10 years as a retiree within the Hanford offsite grid (for a total residential exposure duration of 30 years). As was the case during the 20-year career of the worker, the retired worker still spends 15 days of the year on vacation, at a location beyond the assessment area.

Soil ingestion rates are assumed to be independent of exposure time and, therefore, are not corrected for time spent at work and at home (i.e., the worker consumes 200 mg soil per day at work and 100 mg soil per day at home for a total of 300 mg soil per day, 250 days per year and 100 mg soil per day, 100 days per year).

7.1.6.2 Residential Scenarios

For residential scenarios (resident, resident subsistence farmer, resident subsistence fisher), exposure values are presented in Table 7-3, Table 7-4, and Table 7-5 and are taken primarily from the HHRAP (EPA 2005a). Several exposure parameters (inhalation rate, soil ingestion rate, drinking water ingestion rate) differ from the HHRAP default values in order to be consistent with other EPA Region 10 assessments (CCN 063805, CCN 063806, CCN 063807). The source of each exposure parameter is provided, along with the value used, in Table 7-3, Table 7-4, and Table 7-5.

The adult resident and resident subsistence fisher are assumed to live within the Hanford offsite grid for 30 years. The resident subsistence farmer is assumed to live within the Hanford offsite grid for 40 years. The child is assumed to be exposed for 6 years for all three residential scenarios.

Consumption rates of food are for contaminated food grown at the receptor's home (or, for fish, from the Columbia River maximum) and do not include food purchased from uncontaminated sources. Food consumption rates are presented in units of kg dry weight (DW) produce per kg body weight per day and kg fresh weight (FW) animal product per kg body weight per day. Consumption rates for an adult and child are summarized below (refer to HHRAP Table C-1-2 and C-1-3).

Receptor and Food Product	Consumption Rate[a] (kg/kg·day) Adult	Child
Resident		
Exposed aboveground produce	0.00032	0.00077
Protected aboveground produce	0.00061	0.0015
Belowground produce	0.00014	0.00023
Total produce	0.0011	0.0025
Resident Subsistence Fisher		
Exposed aboveground produce	0.00032	0.00077
Protected aboveground produce	0.00061	0.0015
Belowground produce	0.00014	0.00023
Total produce	0.0011	0.0025
Fish	0.00125	0.00088
Resident Subsistence Farmer		
Exposed aboveground produce	0.00047	0.00113
Protected aboveground produce	0.00064	0.00157
Belowground produce	0.00017	0.00028
Total produce	0.0013	0.0030
Beef	0.00122	0.00075
Pork	0.00055	0.00042
Poultry	0.00066	0.00045
Eggs	0.00075	0.00054
Total meat and eggs	0.0032	0.0022
Dairy	0.01367	0.02268

[a] For the metals mercury, selenium, and cadmium, the concentration in beef, milk, and pork, and the consumption rate are in kilograms dry weight per day (EPA 2005a). Consumption rates include food-preparation loss (refer to discussion below).

The estimated consumption rates are based on food products as purchased or harvested and include food products lost during preparation. Loss during preparation is dependent on the type of food. Preparation loss for produce results from peeling, trimming, washing, and cooking. Losses from these activities are dependent on the type of produce; for example, some produce (e.g., potatoes) may be routinely washed, peeled, and cooked, while other produce (e.g., grapes) may be eaten whole and raw, and still others may be prepared and cooked or eaten whole and raw (e.g., carrots).

Preparation loss from meat (e.g., beef, pork, chicken) results from cutting, shrinkage, excess fat, bones, scraps, and juices, as well as dripping and volatile losses during cooking. Preparation losses for beef are estimated as approximately 27 % from cooking and 24 % from cutting, shrinkage, bones, etc. (EPA 1997a). These losses result in a preparation loss factor (*PL*) of 0.55 [(1 - 0.27) × (1 - 0.24)]. Preparation losses for chicken are estimated as approximately 32 % from cooking and 31 % from cutting, shrinkage, bones, etc. (EPA 1997a). These losses result in a *PL* of 0.47 [(1 - 0.32) × (1 - 0.31)]. Preparation factors for pork are estimated as approximately 28 % from cooking and 36 % from cutting, shrinkage, bones, etc. (EPA 1997a), for a net *PL* of 46%.

Preparation loss does not apply to milk and eggs.

Exposure parameters for the nursing infant are for an infant from ages 0 to 12 months. Exposure parameters for the mother of the nursing infant are the same as those presented for the adult resident and resident subsistence farmer.

7.1.6.3 Resident Subsistence American Indians

For the resident subsistence American Indians , exposure values are presented in Table 7-6 and are taken primarily from the TC&WM EIS (DOE 2009). Other parameters were taken from the EFH (EPA 1997a). Children's exposure parameters were developed by proportioning the child caloric intake reported in EPA guidance (CSEFH, EPA 2008), according to the various proportions of meat, vegetable, roots, etc. in the diet of the adult American Indian hunter-gatherer as reported in the TC&WM EIS.

There are two alternate resident subsistence American Indian scenarios are included in this SLRA that are not necessarily endorsed by the DOE-ORP. These receptor scenarios were developed to more closely represent the lifestyle described by guidance documents issued by local tribes and to address uncertainties associated with the tribal lifestyle derived from the TC&WM EIS. The lifestyle and exposure parameters of the first alternate resident subsistence American Indian are primarily based on data from *Exposure Scenario for CTUIR Traditional Subsistence Lifeways* (Harris and Harper 2004) and *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments* (Harris 2008). The lifestyle and exposure parameters of the second altemate resident subsistence American Indian are primarily based on data from *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* (RUDOLFI Inc. 2007). Other parameters were taken from the "A Native American Exposure Scenario" (Harris and Harper 1997) or from the EFH. Children's exposure parameters were developed by proportioning the child caloric intake reported in the CSEFH according to the various proportions of meat, vegetable, roots, etc. in the diet of the adult American Indian as reported in the guidance documents cited above.

The resident subsistence American Indian resident is assumed to live within the Hanford offsite receptor exposure grid for 70 years. The child is assumed to be exposed for 6 years. Each receptor is presumed to live at the offsite location 365 days/year with the exception of the first alternate resident subsistence

American Indian, who spends 1 day/month at a ceremonial location (assumed to occur at Gable Mountain[5]).

Three separate exposure duration values will be used for this scenario:

- The recommended exposure duration of 70 years assumes that this receptor is exposed during his or her entire lifetime. This exposure duration will be used for adult exposures through all pathways except those noted below. In the current scenario, the receptor is assumed to be exposed during the entire 40-year operating period of the WTP, and the next 30 years after WTP shutdown, at the offsite location. Likewise, while the WTP is in operation, it assumed that the hunting and gathering area is limited, as shown by Area I in Figure 7-2. Once WTP shutdown occurs, the hunting and gathering area is expanded to encompass the region shown as Area II in Figure 7-2. For the future scenario, the receptor is assumed to arrive at the offsite location at the same time as WTP shutdown, and is assumed to spend the entire exposure duration at that location (refer to Section 7.1.3.9). Food of the future receptor is assumed to come from the hunting and gathering Area II, as shown in Figure 7-2.
- An adult exposure duration of 40 years (the operating lifetime of the WTP) will be used for direct exposure to contaminants in air (inhalation and external radiation in air) because these exposures will last only as long as emissions from the WTP are occurring. A 40-year exposure duration will also be used for ingestion of carbon-14 and tritium in plants because these ROPCs are transferred directly to plant tissue from air, rather than being transferred from soil (see Section 6.6), and will only accumulate these ROPCs as long as emissions from the melter are occurring.
- An exposure duration of 6 years will be used for the resident subsistence American Indian child.

The subsistence tribal resident is assumed to obtain wild food gathered from the Hanford site, and in the case of the second subsistence tribal resident, is assumed to complement this diet with homegrown domestic foods. Applicable consumption rates of food presented in below do not include food purchased or collected from uncontaminated sources. Food consumption rates are presented in units of kg dry weight produce per kg body weight per day and kg fresh weight animal product per kg body weight per day. To put these values into perspective, consumption rates for an adult and child are summarized below.

Food Product	Consumption Rate (kg/kg·day) Adult	Child
Subsistence Tribal Resident		
Exposed aboveground produce	0.0025	0.0038
Protected aboveground produce	0.013	0.027
Total produce	0.016	0.031
Wild game	0.0060	0.013

[5] The actual location of tribal ceremonial activities varies with the nature of the activity, and is considered confidential. Gable Mountain is chosen as the location for ceremonial activities in the WTP risk assessment because it is a place of significance and is in close proximity to WTP, making related exposures at this location conservative and bounding.

Food Product	Consumption Rate (kg/kg·day) Adult	Child
Wild fowl eggs	0.00074	0.0022
Fish	0.0088	0.0101
Total meat and eggs	0.016	0.025
Alternate Subsistence Tribal Resident #1		
Exposed aboveground produce	0.0048	0.016
Belowground produce	0.0063	0.021
Total produce	0.011	0.037
Wild game	0.0016	0.0050
Wild game organs	0.00018	0.00056
Wild fowl	0.00089	0.0029
Fish	0.0080	0.025
Fish organs	0.00089	0.0027
Total meat	0.012	0.036
Alternate Subsistence Tribal Resident #2		
Exposed aboveground domestic produce	0.0072	0.0070
Exposed aboveground wild produce	0.0069	0.0067
Belowground wild produce	0.0062	0.0060
Total produce	0.020	0.0197
Beef	0.0040	0.0053
Domestic Poultry	0.0020	0.0026
Wild game	0.0027	0.0036
Wild fowl	0.0013	0.0017
Fish	0.0074	0.023
Total meat and eggs	0.017	0.036

Values have been converted to a per unit weight basis. Consumption rates do not include food preparation loss (refer to discussion below).

Quantitative preparation loss factors are not available for produce, wild game, or wildfowl. Preparation loss for produce will be assumed to be zero. Use of beef/chicken *PL*s could over-estimate losses for wild game and wildfowl because American Indian receptors may utilize more of the animal than other populations, and the ratio of lean meat to fat is typically higher in wild game and wildfowl, potentially resulting in lower preparation losses.

Conversely, the ratio of meat to skin and bone is lower in wild game and wildfowl than domestic beef and chicken, which could result in higher preparation losses. Based on these factors, preparation losses for wild game/wildfowl are estimated to be half that of domestic beef and chicken; thus *PL* factors of 0.76 [(1 – 0.135) × (1 – 0.12)] for wild game and 0.72 [(1 – 0.15) × (1 – 0.15)] for wildfowl will be used (EPA 1997a).

An inhalation rate of 8400 m^3 per year (0.959 m^3/hr) will be used for the resident subsistence American Indian adult per the TC&WM EIS. DOE 1996 reports a child inhalation rate of 15 m^3/day (0.625 m^3/hr). Guidance provided by the CTUIR was used to establish an adult and child inhalation rate of 25 m^3/day (1.04 m^3/hr) and 15 m^3/day (0.625 m^3/hr), respectively, for the alternate resident subsistence American Indian #1. Guidance provided by the Yakama Nation was used to establish an adult and child inhalation rate of 26 m^3/day (1.08 m^3/hr) and 16 m^3/day (0.667m^3/hr), respectively, for the alternate resident subsistence American Indian #2. Exposure parameters for the nursing infant are for an infant ages 0 to 12 months. Exposure parameters for the mother of the nursing infant are the same as those presented for the adult resident subsistence American Indian with the exception of maternal exposure duration which assumed equal to 25 years.

7.1.7 Exposure Point Concentrations

The EPCs used for estimating intakes/doses of both COPCs and ROPCs are dependent on the location of the receptor. The location of the various receptor populations identified for the quantitative risk assessment will correspond to the receptor grid nodes defined during air dispersion modeling (Section 6.1). In keeping with the protective approach for the SLRA, the EPCs used to determine receptor intakes/dose will be location and constituent (carcinogen or noncarcinogen) specific, and incorporate maximum concentration and deposition results as discussed in Section 6.1.4.3.

Air dispersion modeling will be used to identify points of maximum emission concentrations and deposition at three locations of interest[6]: at the onsite location of maximum concentration (i.e., the onsite ground maximum), at Gable Mountain, and at the Columbia River. To simplify the risk assessments, it will be assumed that receptor populations are present at these exposure locations. For example, while offsite residential receptor populations are present (e.g., in Richland), residents may not be onsite, at Gable Mountain, or at the Columbia River maximum. However, for the risk assessment, it is assumed that a variety of residential receptors are present at this location.

The four exposure locations are described in Section 7.1.1 and again, briefly, below (see Figure 7-1):

- Onsite ground maximum
- Hanford offsite
- Gable Mountain maximum
- Columbia River maximum

[6] Exposures in the offsite grid will utilize 90th percentiles to represent exposures that might otherwise be over-predicted by maximum air concentration and deposition values. Due to the migratory nature of game animals, and the diversity of vegetation across the site, the 95% UCL of the median from air dispersion modeling will be used to compute EPCs in the hunting/gathering area(s).

Because the point of maximum concentration may be different for airborne COPCs and ROPCs, and COPCs and ROPCs deposited through wet and dry deposition mechanisms, EPA (2005a) recommends selecting the point of maximum concentration. The EPA also notes that only 1 to 3 receptor grid nodes were typically selected per land use area. For the WTP, emissions will be modeled separately for three stacks (PT, LAW, and HLW Facilities) with nine points of maximum concentration possible from each stack:

- Maximum vapor-phase air concentration
- Maximum particle-phase air concentration (1 micron diameter particles)
- Maximum particle-bound-phase air concentration (2.5 micron diameter particles)
- Maximum vapor-phase wet deposition
- Maximum particle-phase wet deposition (1 micron diameter particles)
- Maximum particle-bound-phase wet deposition (2.5 micron diameter particles)
- Maximum vapor-phase dry deposition
- Maximum particle-phase dry deposition (1 micron diameter particles)
- Maximum particle-bound-phase dry deposition (2.5 micron diameter particles)

Thus, there are a total of 27 possible maximum concentrations (3 stacks × 9 phases) at each of the three locations of interest for each year of air modeling data. Because more than one maximum concentration often occurs at the same receptor grid node, it is more likely that a dozen or so grid nodes with maximum concentrations will be at each location of interest (rather than the 135 possible [3 stacks × 9 phases × 5 years]). Using the highest discrete values of Cyv, Cyp_1, $Cyp_{2.5}$, $Dydv$, $Dydp_1$, $Dydp_{2.5}$, $Dywv$, $Dywp_1$, and $Dywp_{2.5}$ from the onsite maximum, Columbia River, and Gable Mountain grids will result in the highest degree of conservatism. However, in large receptor exposure grids such as the offsite grid, the corresponding exposures to such extreme deposition and air concentrations are improbable and could result in risk estimates that are highly improbable. Accordingly, the 90th percentile of Cyv, Cyp_1, $Cyp_{2.5}$, $Dydv$, $Dydp_1$, $Dydp_{2.5}$, $Dywv$, $Dywp_1$, and $Dywp_{2.5}$ will serve as input to EPC computations. To reflect the migratory nature of game animals and wide dispersion of vegetation, the distribution-free 95 % upper confidence limit of the median provides a sufficiently conservative estimate of air concentration and deposition in the hunter/gatherer area(s).

In order to help quantify the degree of conservatism associated with using the 90th percentile from the offsite grid, the location and species values associated with the point of highest annual total air concentration and deposition will be determined in the uncertainty assessment. The EPCs associated with the grid nodes where these values occur will be computed for comparison to those EPCs computed using 90th percentiles. Results will be discussed in the uncertainty assessment of the PRA (refer to Section 10).

7.1.7.1 Exposure Point Concentrations in Air

The EPCs will be calculated as described in Section 6.1 (air dispersion modeling). Chronic air concentrations are assumed to remain the same for the entire 40-year operating lifetime of the WTP. Acute air concentrations represent the worst-case, one-hour meteorological conditions and will be used for evaluating the acute scenario only (refer to Section 7.2.1.2).

7.1.7.2 Exposure Point Concentrations in Soil, Surface Water, and Sediment

Concentrations of COPCs and ROPCs in soil, surface water, and sediment are estimated from deposition rates predicted by the air dispersion modeling as described in Sections 6.2 (soil), 6.3 (surface water), and 6.4 (sediment). Deposition is assumed to occur for the potential operating lifespan of the facility (40 years), and ceases after WTP shutdown.

Separate soil concentrations will be estimated for the current and future exposure periods for each receptor at the appropriate locations as described in Section 7.1.3. After WTP shutdown, there is no further accumulation of contaminants, so the annual average surface water concentrations are zero for future exposures to these media. Soil and sediment, however, will still contain residual contaminants and thus will contribute to risk in the future scenario.

7.1.7.3 Exposure Point Concentrations in Plants

Exposure point concentrations for produce (fruits and vegetables) and wild plants will be calculated as described in Section 6.6. Current EPCs for homegrown and wild plants will include vapor-phase transfer from air to plants, deposition from air onto plants, and root uptake from soil into the aboveground and belowground portions of plants. Future EPCs for home grown and wild plants will only include root uptake from soil into the above and belowground portions of plants because airborne emissions will not be present following WTP shutdown.

7.1.7.4 Exposure Point Concentrations for Animal Tissue (Domestic Livestock and Wild Game)

Exposure point concentrations in animal products (such as beef, milk, and wild game) will be modeled as described here. As noted in Section 6.7, this modeling effort is slightly different for the human health and ecological risk assessments. See Section 8 for the modeling required for the ecological risk assessment. This section describes the modeling for use in the HHRA and includes modeling to determine EPCs for the following animal tissue:

- Beef
- Milk
- Pork
- Chicken
- Wildfowl
- Chicken eggs
- Wildfowl eggs
- Wild game (e.g., deer)

Edible tissue concentrations will be calculated for the HHRA using feed concentrations, ingestion rates, bioaccumulation factors, and other parameters in model equations from EPA 2005a. Current and future feed concentrations (such as soil, forage, silage, and grain concentrations) will be determined as described in Section 6.6. Ingestion rates and other parameters are generally from the HHRAP (EPA 2005a) and can be found in Table 7-9. Bioaccumulation factors are COPC- and ROPC-specific and can be found in Supplement 4. As with the plant modeling (see Section 6.6.3), the bioaccumulation factors used to model

animal tissue and animal products must be corrected to account for mass balance. The mass balance correction for animal tissue is presented at the end of this section.

Exposure Point Concentrations in Beef

Beef cattle are assumed to consume forage, silage, and grain, as well as surface soil (i.e., 2 cm untilled soil). The equation to determine concentrations in beef tissue (EPA 2005a) for all constituents is:

$$A_{beef} = \left[\left(\sum_{i=1}^{3} F_i \cdot Qp_{i(beef)} \cdot P_i\right) + Qs_{soil(beef)} \cdot Cs_2 \cdot Bs\right] \cdot Ba_{beef} \cdot MF \qquad \text{(HHRAP Table B-3-10)}$$

where:

A_{beef} = concentration of COPC or ROPC in beef (mg/kg for COPCs and pCi/g for ROPCs)

F_i = fraction of plant-type i grown on contaminated soil and ingested by the beef cattle (unitless). The three plant types consumed by the beef cattle are forage, silage, and grain. The recommended default value of 1.0 (EPA 2005a) shown in Table 7-9 as F_{plant} is used for all plant types.

$Qp_{i(beef)}$ = quantity of plant type i eaten by the beef cattle per day (kg/day). $Qp_{i(beef)}$ is shown in Table 7-9. The recommended values (EPA 2005a) for beef cattle raised by subsistence farmers are used: $Qp_{forage(beef)}$ = 8.8 kg/day is the amount of forage eaten by the beef cow, $Qp_{silage(beef)}$ = 2.5 kg/day for is the amount of silage eaten by the beef cow, and $Qp_{grain(beef)}$ = 0.47 kg/day is the amount of grain eaten by the beef cow.

P_i = concentration of COPC or ROPC in plant type i that is ingested by the beef cattle (mg/kg for COPCs and pCi/g for ROPCs). P_i is COPC- and ROPC-specific and calculated as follows:

$$P_{forage} = Pd_{forage} + Pv_{forage} + Pr_{ag(forage)}$$
$$P_{silage} = Pd_{silage} + Pv_{silage} + Pr_{ag(silage)}$$
$$P_{domestic\ grain} = Pr_{ag(domestic\ grain)}$$

where, for all constituents except carbon-14 and tritium:

Pd_{forage} and Pd_{silage} are calculated in Eq. 5-14 in the HHRAP

Pv_{forage} and Pv_{silage} are calculated in Eq. 5-18 in the HHRAP

$Pr_{ag(forage)}$ is calculated in Eq. 5-20A in the HHRAP using 15 cm soil (root-zone)

$Pr_{ag(silage)}$ and $Pr_{ag(domestic\ grain)}$ are calculated in Eq. 5-20A in the HHRAP using 20 cm soil (tilled)

For carbon-14, all plant concentrations (i.e., P_{forage}, Pr_{silage}, and Pr_{grain}) take on the plant concentration value, $C_{V(C\text{-}14)}$, calculated from air concentration as described by the Nuclear Regulatory Commission (NRC) (1977) (see Section 6.6.2). For tritium, all plant concentrations take on the plant concentration value, $C_{V(H\text{-}3)}$,

calculated from air concentration and absolute humidity as described by the NRC (1977) (see Section 6.6.2).

In the future scenario, Pd, Pv, $C_{V(C\text{-}14)}$, and $C_{V(H\text{-}3)}$ are all zero because there are no longer any emissions (no direct deposition or air-to-plant uptake).

$Qs_{soil(beef)}$ = quantity of soil ingested by the beef cattle (kg/day). The recommended default value of 0.5 kg/day (EPA 2005a) is used (see Table 7-9 of this work plan).

Cs_2 = soil concentration at the 2 cm soil depth (mg/kg for COPCs and pCi/g for ROPCs) calculated according to Section 6.2

Bs = soil bioavailability factor (unitless). The recommended default value of 1.0 (EPA 2005a) is used (see Table 7-9).

Ba_{beef} = biotransfer factor for beef (day/kg). Ba_{beef} is COPC- and ROPC-specific and shown in Supplement 4. If no value is available for Ba_{beef}, then A_{beef} cannot be calculated and the ingestion of beef pathway cannot be evaluated in the HHRA. The values for Ba_{beef} in Supplement 4 will be compared against the calculated mass-limited uptake factor for beef (shown in Appendix A) and the smaller of the two values will be used in the calculation of the beef concentration (A_{beef}).

MF = metabolism factor (unitless). MF is COPC- and ROPC-specific. The recommended default MF values of 0.01 for bis(2-ethylhexyl)phthalate and 1.0 for all other constituents (EPA 2005a) are used (see Table 7-9).

Exposure Point Concentration in Milk

Dairy cattle are assumed to consume forage, silage, and grain, as well as surface soil (i.e., 2 cm untilled soil). The equation to determine concentrations in milk (EPA 2005a) for all constituents is:

$$A_{milk} = \left[\left(\sum_{i=1}^{3} F_i \cdot Qp_{i(milk)} \cdot P_i\right) + Qs_{soil(milk)} \cdot Cs_2 \cdot Bs\right] \cdot Ba_{milk} \cdot MF \qquad \text{(HHRAP Table B-3-11)}$$

where:

A_{milk} = concentration of COPC or ROPC in milk (mg/kg for COPCs and pCi/g for ROPCs).

F_i = fraction of plant-type i grown on contaminated soil and ingested by dairy cattle (unitless). The three plant types consumed by the dairy cattle are forage, silage, and grain. The recommended default value of 1.0 (EPA 2005a) shown in Table 7-9 as F_{plant} is used for all plant types.

$Qp_{i(milk)}$ = quantity of plant type i eaten by the dairy cattle per day (kg/day). $Qp_{i(milk)}$ is shown in Table 7-9. The recommended values (EPA 2005a) for dairy cattle raised by subsistence farmers are used: $Qp_{forage(milk)}$ = 13.2 kg/day is the amount of forage eaten by the dairy cow, $Qp_{silage(milk)}$ = 4.1 kg/day is the amount of silage eaten by the dairy cow, and $Qp_{grain(milk)}$ = 3.0 kg/day is the amount of grain eaten by the dairy cow.

P_i = concentration of COPC or ROPC in plant type i that is ingested by the dairy cattle (mg/kg for COPCs and pCi/g for ROPCs). P_i is COPC- and ROPC-specific and calculated as follows:

$$P_{forage} = Pd_{forage} + Pv_{forage} + Pr_{ag(forage)}$$
$$P_{silage} = Pd_{silage} + Pv_{silage} + Pr_{ag(silage)}$$
$$P_{domestic\ grain} = Pr_{ag(domestic\ grain)}$$

where, for all constituents except carbon-14 and tritium:

Pd_{forage} and Pd_{silage} are calculated in Eq. 5-14 in the HHRAP

Pv_{forage} and Pv_{silage} are calculated in Eq. 5-18 in the HHRAP

$Pr_{ag(forage)}$ is calculated in Eq. 5-20A in the HHRAP using 15 cm soil (root-zone)

$Pr_{ag(silage)}$ and $Pr_{ag(domestic\ grain)}$ are calculated in Eq. 5-20A in the HHRAP using 20 cm soil (tilled)

For carbon-14, all plant concentrations (i.e., P_{forage}, Pr_{silage}, and $Pr_{domestic\ grain}$) take on the plant concentration, $C_{V(C-14)}$, calculated from air concentration as described by the NRC (1977) (see Section 6.6.2). For tritium, all plant concentrations take on the plant concentration value, $C_{V(H-3)}$, calculated from air concentration and absolute humidity as described by the NRC (1977) (see Section 6.6.2).

In the future scenario, Pd, Pv, $C_{V(C-14)}$, and $C_{V(H-3)}$ are all zero because there are no longer any emissions (no direct deposition or air-to-plant uptake).

$Qs_{soil(milk)}$ = quantity of soil ingested by the dairy cattle (kg/day). The recommended default value of 0.4 kg/day (EPA 2005a) is used (see Table 7-9).

Cs_2 = soil concentration at the 2 cm soil depth (mg/kg for COPCs and pCi/g for ROPCs) calculated according to Section 6.2

Bs = soil bioavailability factor (unitless). The recommended default value of 1.0 (EPA 2005a) is used (see Table 7-9).

Ba_{milk} = biotransfer factor for milk (day/kg). Ba_{milk} is COPC- and ROPC-specific and shown in Supplement 4. If no value is available for Ba_{milk}, then A_{milk} cannot be calculated, and the ingestion of milk pathway cannot be evaluated in the HHRA. The values for Ba_{milk} in Supplement 4 will be compared against the calculated mass-limited uptake factor for milk (shown in Appendix A), and the smaller of the two values will be used in the calculation of the milk concentration (A_{milk}).

MF = metabolism factor (unitless). MF is COPC- and ROPC-specific. The recommended default MF values of 0.01 for bis(2-ethylhexyl)phthalate and 1.0 for all other constituents (EPA 2005a) are used (see Table 7-9).

Exposure Point Concentration in Pork

Swine are assumed to consume silage and grain, as well as surface soil (i.e., 2 cm untilled soil). The equation to determine pork concentrations (EPA 2005a) for all constituents is:

$$A_{pork} = \left[\left(\sum_{i=2}^{3} F_i \cdot Qp_{i(pork)} \cdot P_i\right) + Qs_{soil(pork)} \cdot Cs_2 \cdot Bs\right] \cdot Ba_{pork} \cdot MF \qquad \text{(HHRAP Table B-3-12)}$$

where:

A_{pork} = concentration of COPC or ROPC in pork (mg/kg for COPCs and pCi/g for ROPCs)

F_i = fraction of plant-type i grown on contaminated soil and ingested by the swine (unitless). The two plant types consumed by the swine are silage and grain. The recommended default value of 1.0 (EPA 2005a) shown in Table 7-9 as F_{plant} is used for both plant types.

$Qp_{i(pork)}$ = quantity of plant type i eaten by the swine per day (kg/day). Qp_i is shown in Table 7-9. The recommended values (EPA 2005a) for swine raised by subsistence farmers are used: $Qp_{silage(pork)}$ = 1.4 kg/day is the amount of silage eaten by the swine, and $Qp_{grain(pork)}$ = 3.3 kg/day is the amount of grain eaten by the swine.

P_i = concentration of COPC or ROPC in plant type i that is ingested by the swine (mg/kg for COPCs and pCi/g for ROPCs). P_i is COPC- and ROPC-specific and calculated as follows:

$$P_{silage(pork)} = Pd_{silage} + Pv_{silage} + Pr_{ag(silage)}$$
$$P_{domestic\ grain} = Pr_{ag(domestic\ grain)}$$

where, for all constituents except carbon-14 and tritium:

Pd_{silage} is calculated in Eq. 5-14 in the HHRAP

Pv_{silage} is calculated in Eq. 5-18 in the HHRAP

$Pr_{ag(silage)}$ and $Pr_{ag(domestic\ grain)}$ are calculated in Eq. 5-20A in the HHRAP using 20 cm soil (tilled)

For carbon-14, both plant concentrations (i.e., Pr_{silage} and $Pr_{domestic\ grain}$) take on the plant concentration value, $C_{V(C\text{-}14)}$, calculated from air concentration as described by the NRC (1977), see Section 6.6.2. For or tritium, both plant concentrations take on the plant concentration value, $C_{V(H\text{-}3)}$, calculated from air concentration and absolute humidity as described by the NRC (1977) (see Section 6.6.2).

In the future scenario, Pd, Pv, $C_{V(C\text{-}14)}$, and $C_{V(H\text{-}3)}$ are all zero because there are no longer any emissions (no direct deposition or air-to-plant uptake).

$Qs_{soil(pork)}$ = quantity of soil ingested by the swine (kg/day). The recommended default value of 0.37 kg/day (EPA 2005a) is used (see Table 7-9).

Cs_2 = soil concentration at the 2 cm soil depth (mg/kg for COPCs and pCi/g for ROPCs) calculated according to Section 6.2.

Bs = soil bioavailability factor (unitless). The recommended default value of 1.0 (EPA 2005a) is used (see Table 7-9).

Ba_{pork} = biotransfer factor for pork (day/kg). Ba_{pork} is COPC- and ROPC-specific and shown in Supplement 4. If no value is available for Ba_{pork}, then A_{pork} cannot be calculated, and the ingestion of pork pathway cannot be evaluated in the HHRA. The values for Ba_{pork} in Supplement 4 will be compared against the calculated

mass-limited uptake factor for pork (shown in Appendix A), and the smaller of the two values will be used in the calculation of the pork concentration (A_{pork}).

MF = metabolism factor (unitless). MF is COPC- and ROPC-specific. The recommended default MF values of 0.01 for bis(2-ethylhexyl)phthalate and 1.0 for all other constituents (EPA 2005a) are used (see Table 7-9).

Exposure Point Concentration in Chicken

Chickens are assumed to consume grain grown on a farm, as well as surface soil (i.e., 2 cm untilled soil). The grain eaten by chickens is grown in tilled (20 cm depth) soil. The equation to determine chicken concentrations (EPA 2005a) for all constituents is:

$$A_{chicken} = \left(F_{grain} \cdot Qp_{grain(chicken)} \cdot P_{domestic\ grain} + Qs_{soil(chicken)} \cdot Cs_2 \cdot Bs\right) \cdot Ba_{chicken} \qquad \text{(HHRAP Table B-3-14)}$$

where:

$A_{chicken}$ = concentration of COPC or ROPC in chicken meat (mg/kg for COPCs and pCi/g for ROPCs).

F_{grain} = fraction of grain grown on contaminated soil and ingested by the chicken (unitless). The recommended default value of 1.0 (EPA 2005a) shown in Table 7-9 as F_{plant} is used for grain.

$Qp_{grain(chicken)}$ = quantity of grain eaten by the chicken per day (kg/day). The recommended value of $Qp_{grain(chicken)}$ = 0.2 kg/day (EPA 2005a) shown in Table 7-9 for chickens raised by subsistence farmers is used.

$P_{domestic\ grain}$ = concentration of COPC or ROPC in grain that is ingested by the chicken (mg/kg for COPCs and pCi/g for ROPCs). $P_{domestic\ grain}$ is COPC- and ROPC-specific and calculated as follows:

$$P_{domestic\ grain} = Pr_{ag(domestic\ grain)}$$

where, for all constituents except carbon-14 and tritium:

$Pr_{ag(grain)}$ is calculated in Eq. 5-20A in the HHRAP using 20 cm soil (tilled).

For carbon-14 and tritium, $Pr_{domestic\ grain}$ takes on the plant concentration value, $C_{V(C\text{-}14)}$ or $C_{V(H\text{-}3)}$, calculated from calculated from air concentration as described by the NRC (1977), respectively (see Section 6.6.2).

$Qs_{soil(chicken)}$ = quantity of soil ingested by the chicken (kg/day); the recommended default value of 0.022 kg/day (EPA 2005a) is used (see Table 7-9).

Cs_2 = soil concentration at the 2 cm soil depth (mg/kg for COPCs and pCi/g for ROPCs) calculated according to Section 6.2.

Bs = soil bioavailability factor (unitless); the recommended default value of 1.0 (EPA 2005a) is used (see Table 7-9).

$Ba_{chicken}$ = biotransfer factor for chicken (day/kg); $Ba_{chicken}$ is COPC- and ROPC-specific and shown in Supplement 4. If no value is available for $Ba_{chicken}$, then $A_{chicken}$

cannot be calculated, and the ingestion of chicken pathway cannot be evaluated in the HHRA. The values for $Ba_{chicken}$ in Supplement 4 will be compared against the calculated mass-limited uptake factor for poultry (shown in Appendix A), and the smaller of the two values will be used in the calculation of the chicken concentration ($A_{chicken}$).

Exposure Point Concentration in Wildfowl

Wildfowl are assumed to consume grain grown in the wild, as well as surface soil (i.e., 2 cm untilled soil). The grain eaten by wildfowl is grown in root-zone (15 cm depth) soil. The equation to determine wildfowl concentrations (EPA 2005a) for all constituents is:

$$A_{fowl} = \left(F_{grain} \cdot Qp_{grain(chicken)} \cdot P_{wild\ grain} + Qs_{soil(chicken)} \cdot Cs_2 \cdot Bs\right) \cdot Ba_{fchicken}$$ (HHRAP Table B-3-14)

where:

A_{fowl} = concentration of COPC or ROPC in wildfowl (mg/kg for COPCs and pCi/g for ROPCs).

F_{grain} = fraction of grain grown on contaminated soil and ingested by the wildfowl (unitless). The recommended default value of 1.0 (EPA 2005a) shown in Table 7-9 as F_{plant} is used for grain.

$Qp_{grain(chicken)}$ = quantity of grain eaten by the wildfowl per day (kg/day). The recommended value of $Qp_{grain(chicken)}$ = 0.2 kg/day (EPA 2005a value for chickens) shown in Table 7-9 is used for wildfowl.

$P_{wild\ grain}$ = concentration of COPC or ROPC in grain that is ingested by the wildfowl (mg/kg for COPCs and pCi/g for ROPCs). $P_{wild\ grain}$ is COPC- and ROPC-specific and calculated as follows:

$$P_{wild\ grain} = Pr_{ag(wild\ grain)}$$

where, for all constituents except carbon-14 and tritium:

$Pr_{ag(wild\ grain)}$ is calculated in Eq. 5-20A in the HHRAP using 15 cm soil (root-zone).

For carbon-14 and tritium, $P_{wild\ grain}$ takes on the plant concentration value, $C_{V(C\text{-}14)}$ or $C_{V(H\text{-}3)}$, calculated from calculated from air concentration as described by the NRC (1977), respectively (see Section 6.6.2).

$Qs_{soil(chicken)}$ = quantity of soil ingested by the wildfowl (kg/day); the recommended default value of 0.022 kg/day (EPA 2005a value for chickens) shown in Table 7-9 is used for wildfowl.

Cs_2 = soil concentration at the 2 cm soil depth (mg/kg for COPCs and pCi/g for ROPCs) calculated according to Section 6.2.

Bs = soil bioavailability factor (unitless). The recommended default value of 1.0 (EPA 2005a) is used (see Table 7-9).

$Ba_{chicken}$ = biotransfer factor for wild fowl (day/kg). $Ba_{chicken}$ is COPC- and ROPC-specific and shown in Supplement 4. If no value is available for $Ba_{chicken}$, then A_{fowl} cannot be calculated, and the ingestion of wildfowl pathway cannot be evaluated in the HHRA. The values for $Ba_{chicken}$ in Supplement 4 will be compared against the calculated mass-limited uptake factor for poultry (shown in Appendix A), and the smaller of the two values will be used in the calculation of the wildfowl concentration (A_{fowl}).

Exposure Point Concentration in Chicken Eggs

Chicken eggs are from chickens that are assumed to consume grain grown on a farm in tilled (20 cm depth) soil as well as surface soil (i.e., 2 cm untilled soil). The equation to determine chicken egg concentrations (EPA 2005a) for all constituents is:

$$A_{egg} = \left(F_{grain} \cdot Qp_{grain(chicken)} \cdot P_{domestic\ grain} + Qs_{soil(chicken)} \cdot Cs_2 \cdot Bs\right) \cdot Ba_{egg} \qquad \text{(HHRAP Table B-3-13)}$$

where:

A_{egg} = concentration of COPC or ROPC in chicken eggs (mg/kg for COPCs and pCi/g for ROPCs).

F_{grain} = fraction of grain grown on contaminated soil and ingested by the chicken (unitless). The recommended default value of 1.0 (EPA 2005a) shown in Table 7-9 as F_{plant} is used for grain.

$Qp_{grain(chicken)}$ = quantity of grain eaten by the chicken per day (kg/day). The recommended value of $Qp_{grain(chicken)}$ = 0.2 kg/day (EPA 2005a) shown in Table 7-9 for chickens raised by subsistence farmers is used.

$P_{domestic\ grain}$ = concentration of COPC or ROPC in grain that is ingested by the chicken (mg/kg for COPCs and pCi/g for ROPCs). $P_{domestic\ grain}$ is COPC- and ROPC-specific and calculated as follows:

$$P_{domestic\ grain} = Pr_{ag(domestic\ grain)}$$

where, for all constituents except carbon-14 and tritium:

$Pr_{ag(domestic\ grain)}$ is calculated in Eq. 5-20A in the HHRAP using 20 cm soil (tilled).

For carbon-14 and tritium, $Pr_{grain(chicken)}$ takes on the plant concentration value, $C_{V(C\text{-}14)}$ or $C_{V(H\text{-}3)}$, calculated from calculated from air concentration as described by the NRC (1977), respectively (see Section 6.6.2).

$Qs_{soil(chicken)}$ = quantity of soil ingested by the chicken (kg/day). The recommended default value of 0.022 kg/day (EPA 2005a) is used (see Table 7-9).

Cs_2 = soil concentration at the 2 cm soil depth (mg/kg for COPCs and pCi/g for ROPCs) calculated according to Section 6.2

Bs = soil bioavailability factor (unitless). The recommended default value of 1.0 (EPA 2005a) is used (see Table 7-9).

Ba_{egg} = biotransfer factor for chicken eggs (day/kg). Ba_{egg} is COPC- and ROPC-specific and shown in Supplement 4. If no value is available for Ba_{egg}, then A_{egg} cannot be calculated, and the ingestion of chicken eggs pathway cannot be evaluated in the HHRA. The values for Ba_{egg} in Supplement 4 will be compared against the calculated mass-limited uptake factor for eggs (shown in Appendix A), and the smaller of the two values will be used in the calculation of the chicken egg concentration (A_{egg}).

Exposure Point Concentration in Wildfowl Eggs

Wildfowl eggs are from wildfowl, which are assumed to consume grain grown in the wild in root-zone (15 cm depth) soil, as well as surface soil (i.e., 2 cm untilled soil). The equation to determine wildfowl egg concentrations (EPA 2005a) for all constituents is:

$$A_{egg(fowl)} = \left(F_{grain} \cdot Qp_{grain(chicken)} \cdot P_{wild\ grain} + Qs_{soil(chicken)} \cdot Cs_2 \cdot Bs\right) \cdot Ba_{egg} \qquad \text{(HHRAP Table B-3-13)}$$

where:

$A_{egg(fowl)}$ = concentration of COPC or ROPC in wildfowl eggs (mg/kg for COPCs and pCi/g for ROPCs).

F_{grain} = fraction of grain grown on contaminated soil and ingested by the wildfowl (unitless). The recommended default value of 1.0 (EPA 2005a) shown in Table 7-9 as F_{plant} is used for grain.

$Qp_{grain(chicken)}$ = quantity of grain eaten by the wildfowl per day (kg/day). The recommended value of $Qp_{grain(chicken)}$ = 0.2 kg/day (EPA 2005a value for chickens) shown in Table 7-9 is used for wildfowl.

$P_{wild\ grain}$ = concentration of COPC or ROPC in grain that is ingested by the wildfowl (mg/kg for COPCs and pCi/g for ROPCs). $P_{wild\ grain}$ is COPC- and ROPC-specific, site-specific, plant type-specific, and calculated as follows:

$$P_{wild\ grain} = \mathrm{Pr}_{ag(wild\ grain)}$$

where, for all constituents except carbon-14 and tritium:

$\mathrm{Pr}_{ag(wild\ grain)}$ is calculated in Eq. 5-20A in the HHRAP using 15 cm soil (root-zone).

For carbon-14 and tritium, $P_{wild\ grain}$ takes on the plant concentration value, $C_{V(C\text{-}14)}$ or $C_{V(H\text{-}3)}$, calculated from calculated from air concentration as described by the NRC (1977), respectively (see Section 6.6.2).

$Qs_{soil(chicken)}$ = quantity of soil ingested by the wildfowl (kg/day). The recommended default value of 0.022 kg/day (EPA 2005a value for chickens) shown in Table 7-9 is used for wildfowl.

Cs_2 = soil concentration at the 2 cm soil depth (mg/kg for COPCs and pCi/g for ROPCs). Cs_2 is COPC- and ROPC-specific, site-specific, and calculated according to Section 6.2.

Bs = soil bioavailability factor (unitless). The recommended default value of 1.0 (EPA 2005a) is used (see Table 7-9).

Ba_{egg} = biotransfer factor for wildfowl eggs (day/kg). Ba_{egg} is COPC- and ROPC-specific and shown in Supplement 4. If no value is available for Ba_{egg}, then $A_{egg(fowl)}$ cannot be calculated and the ingestion of wildfowl eggs pathway cannot be evaluated in the HHRA. The values for Ba_{egg} in Supplement 4 will be compared against the calculated mass-limited uptake factor for eggs (shown in Appendix A), and the smaller of the two values will be used in the calculation of the wildfowl egg concentration ($A_{egg(fowl)}$).

Exposure Point Concentration in Wild Game

Wild game animals (such as deer) are assumed to consume forage grown in root-zone (15 cm) soil only. The equation used to determine the concentration in wild game is adopted from the equation used for beef, only the contribution of silage and grain is not included since those feeds are unique to domestic livestock. The equation to determine concentrations in game tissue (EPA 2005a) for all constituents is:

$$A_{game} = \left(F_{forage} \cdot Qp_{forage(deer)} \cdot P_{forage}\right) \cdot Ba_{deer} \cdot MF \qquad \text{(modified HHRAP Table B-3-13)}$$

where:

A_{game} = concentration of COPC or ROPC in wild game animals (mg/kg for COPCs and pCi/g for ROPCs).

F_{forage} = fraction of forage grown on contaminated soil and ingested by the wild game animals (unitless). The recommended default value of 1.0 (EPA 2005a) shown in Table 7-9 as F_{plant} is used for forage.

$Qp_{forage(deer)}$ = quantity of forage eaten by the wild game animals per day (kg/day). A calculated value of $Qp_{forage(deer)}$ = 1.463 kg/day (using values from Sample et al. 1997 [66.5 kg × 0.022 kg/kg/day], refer to Section 8.1.3.3, mule deer species profile[7]) is used for wild game animals.

P_{forage} = concentration of COPC or ROPC in forage that is ingested by the wild game animals (mg/kg for COPCs and pCi/g for ROPCs). P_{forage} is COPC- and ROPC-specific and calculated as follows:

$$P_{forage} = Pd_{forage} + Pv_{forage} + Pr_{ag(forage)}$$

where, for all constituents except carbon-14 and tritium:

Pd_{forage} is calculated in Eq. 5-14 in the HHRAP.

Pv_{forage} is calculated in Eq. 5-18 in the HHRAP.

$Pr_{ag(forage)}$ is calculated in Eq. 5-20A in the HHRAP using 15 cm soil (root-zone).

[7] Note, the ecological assessment uses fresh weights while the human health assessment uses dry weights for food quantity of forage eaten.

For carbon-14 and tritium, P_{forage} takes on the plant concentration value, $C_{V(C-14)}$ or $C_{V(H-3)}$, calculated from calculated from air concentration as described by the NRC (1977), respectively (see Section 6.6.2).

In the future scenario, Pd, Pv, $C_{V(C-14)}$, and $C_{V(H-3)}$ are all zero because there are no longer any emissions (no direct deposition or air-to-plant uptake).

Ba_{deer} = biotransfer factor for wild game animals (day/kg). Ba_{deer} is COPC- and ROPC-specific. The biotransfer factor for beef is used as a surrogate biotransfer factor for wild game animals and is shown (as Ba_{beef}) in Supplement 4. If no value is available for Ba_{beef}, then A_{game} cannot be calculated, and the ingestion of game pathway cannot be evaluated in the HHRA. The values for Ba_{beef} in Supplement 4 will be compared against the calculated mass-limited uptake factor for beef (shown in Appendix A), and the smaller of the two values will be used in the calculation of the wild game concentration (A_{game}).

MF = Metabolism factor (unitless). MF is COPC- and ROPC-specific. The recommended default MF values of 0.01 for bis (2-ethylhexyl) phthalate and 1.0 for all other constituents (EPA 2005a) are used (See Table 7-9).

Exposure Point Concentration in Wild Game Organs

Guidance in *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments* (Harris 2008) recommends the inclusion of game organs in the diet described by the traditional tribal lifestyle. This reference states that animal organs are eaten, and those organs can have bioconcentrated some contaminants by as much as 10-fold. Therefore, for scenarios where the pathway applies, game organ concentration shall be taken as 10 times the equivalent game meat concentration.

$$A_{game\ organs} = 10 \times A_{game}$$

where:

$A_{game\ organs}$ = concentration of COPC or ROPC in wild game animal organs (mg/kg for COPCs and pCi/g for ROPCs).

A_{game} = concentration of COPC or ROPC in wild game animals (mg/kg for COPCs and pCi/g for ROPCs).

Feed-to-Animal Tissue Biotransfer Factors: Mass Balance Issues

The HHRAP recommended sources for uptake factors (Ba) for organic chemicals sometimes result in animals predicted to take up more chemical into their tissues than is present in their food.

For example, for n-dioctyl phthalate, using the default uptake factors, more chemical is predicted to accumulate in beef cattle than is available in their feed. Using an assumed soil concentration of 1E-08 mg/kg, the total mass of n-dioctyl phthalate in soil and feed ingested by a steer is 49 mg (calculated as [the sum of concentration of n-dioctyl phthalate in soil and food, such as silage, grain, and forage] × [respective consumption rate of soil and food] × [730 days exposure duration to raise a steer to market weight]). Using the recommended default uptake factor for beef (7.77 kg/day in the HHRAP database), the predicted total mass of n-dioctyl phthalate in the beef is 296 mg (calculated as [the sum of concentration of n-dioctyl phthalate in soil and food, such as silage, grain, and forage] × [respective

consumption rate of soil and food] × [default beef uptake factor for n-dioctyl phthalate] × [567 kg, the average live weight for cattle taken to slaughter]). Thus, for a given concentration of n-dioctyl phthalate in soil and feed, cattle are predicted to take up more than 6 times the amount of n-dioctyl phthalate than is available in the soil and feed that is ingested over a two-year period (i.e., 296 mg in beef/49 mg in feed).

A conservative solution to this mass balance problem is to calculate an uptake factor that allows 100 % of the available chemical to transfer to animal tissue, but no more. This mass-limited uptake factor is not chemical-specific but rather it is a function of exposure duration and body weight. The feed-to-animal tissue mass-limited uptake factor is calculated as:

Feed-to-Animal Tissue Uptake Factor = (Exposure Duration) ÷ (Tissue Weight) (Equation 7-2)

where:

Uptake Factor	=	mass-limited feed-to-animal tissue uptake factor (days/kg)
Exposure Duration	=	duration to bring animal to market weight (days)
Tissue Weight	=	total mass of animal at market weight (kg)

This mass-limited uptake factor assumes that the animals concentrate the entire mass of chemical ingested into their edible tissue, with no degradation or excretion of the chemical over the exposure duration period. This mass-limited uptake factor can be used to calculate a conservative estimate of potential dose and risk to human receptors without defying the law of conservation of mass.

The equation above is used to estimate mass-limited feed-to-animal tissue uptake factors for beef, pork, and poultry. Estimating a mass-limited feed-to-animal uptake factor for animal products (i.e., milk and eggs) is slightly different. The mass-limited feed-to-animal product uptake factor is a function of the daily product weight for the animal. The equation for the mass-limited feed-to-animal product uptake factor is:

Feed-to-Animal Product Uptake Factor = 1 ÷ (Daily Product Weight) (Equation 7-3)

where:

Uptake Factor	=	mass-limited feed-to-animal product uptake factor (days/kg)
Daily Product Weight	=	total expected weight of animal product each day (kg/day)

This equation is used to estimate mass-limited feed-to-animal product uptake factors for milk and eggs. All calculated feed-to-animal tissue/product mass-limited uptake factors are shown in Appendix A, Section A.5.2. The final step in this mass-limited uptake factor approach is to compare the uptake factors as specified in the HHRAP (EPA 2005a) to the calculated mass-limited uptake factors, on a chemical-by-chemical basis for organic COPCs. The lesser of the two values will be used in the estimation of animal tissue/product concentrations.

7.1.7.5 Exposure Point Concentrations in Fish

Exposure point concentrations in fish tissue for the human health evaluation will be modeled as described here. As noted in Section 6.7, this modeling effort is slightly different for the human health and ecological risk assessments. See Section 8 for the modeling required for the ecological risk assessment.

This section describes the models that will be used to calculate fish tissue concentrations and the uptake factors to be used in these models.

The COPCs and ROPCs in fish will be estimated using the equations presented below as recommended by EPA (2005a). The ROPCs will be evaluated using equations similar to those presented for COPCs in EPA (2005a). Values for the chemical-specific parameters are presented in Supplement 4; other parameter values are presented in Table 7-9. It should be noted that the Hanford Surface Environmental Surveillance Program collects and analyzes fish tissues from the Hanford Reach of the Columbia River. However, since the SLRA will be conducted prior to release of emissions from the WTP, the fish data collected does not represent contamination contributed by the WTP and thus cannot be used to calibrate the fish model.

For organic COPCs other than dioxins, furans, and PCBs, where log K_{ow} is less than 4, and all inorganic COPCs and ROPCs with values for BAF, fish concentrations will be estimated as:

COPCs: $C_{fish} = C_{dw} \cdot BCF_{fish}$ (HHRAP Table B-4-26)

$C_{organs} = C_{dw} \cdot BCF_{organs}$

ROPCs: $C_{fish} = CF \cdot C_{dw} \cdot BCF_{fish}$ (HHRAP Table B-4-26)

$C_{organs} = CF \cdot C_{dw} \cdot BCF_{organs}$

where:

C_{fish} = concentration of COPC or ROPC in fish muscle tissue (mg/kg for COPCs and pCi/g for ROPCs).

C_{organs} = concentration of COPC or ROPC in fish organs (mg/kg for COPCs and pCi/g for ROPCs) C_{dw} = dissolved-phase water concentration (mg/L for COPCs or pCi/L for ROPCs) calculated in Table B-4-24 of the HHRAP.

BCF_{fish} = bioconcentration factor for COPCs and ROPCs in fish (L/kg). BCF_{fish} is COPC- and ROPC-specific and is shown in Supplement 4.

BCF_{organs} = organ-specific bioconcentration factor for COPCs and ROPCs in fish (L/kg), if available. BCF_{organs} is COPC- and ROPC-specific and is shown in Supplement 4.

CF = units conversion factor of 10^{-3} (kg/g), used for ROPCs only.

For organic COPCs other than dioxins, furans, and PCBs, where log K_{ow} is greater than 4, and all inorganic COPCs and ROPCs with values for BAF, fish concentrations will be estimated as:

COPCs: $C_{fish} = C_{dw} \cdot BAF_{fish}$ (HHRAP Table B-4-27)

$C_{organs} = C_{dw} \cdot BAF_{organs}$

ROPCs: $C_{fish} = CF \cdot C_{dw} \cdot BAF_{fish}$ (HHRAP Table B-4-27)

$C_{organs} = CF \cdot C_{dw} \cdot BAF_{organs}$

where:

C_{fish} = concentration of COPC or ROPC in fish muscle tissue (mg/kg for COPCs and pCi/g for ROPCs).

C_{organs} = concentration of COPC or ROPC in fish organs (mg/kg for COPCs and pCi/g for ROPCs).

C_{dw} = dissolved-phase water concentration (mg/L for COPCs or pCi/L for ROPCs) calculated in Table B-4-24 of the HHRAP.

BAF_{fish} = bioaccumulation factor for COPCs and ROPCs in fish (L/kg). BAF_{fish} is COPC- and ROPC-specific and is shown in Supplement 4.

BAF_{organs} = organ-specific bioaccumulation factor for COPCs and ROPCs in fish (L/kg), if available. BAF_{organs} is COPC- and ROPC-specific and is shown in Supplement 4.

CF = units conversion factor of 10^{-3} (kg/g), used for ROPCs only.

Divalent mercury in the fish is assumed to exist or be converted to the methyl mercury (organic) form after uptake into the fish tissue (EPA 2005a). Therefore, the fish concentration of mercury will be calculated using the equation in Table B-4-27 of the HHRAP:

$$C_{fish_{MHg}} = C_{organs_{MHg}} = C_{dw_{MHg}} \cdot BAF_{fish_{MHg}}$$

$$C_{fish_{Hg^{2+}}} = C_{organs_{Hg^{2+}}} = C_{dw_{Hg^{2+}}} \cdot BAF_{fish_{Hg^{2+}}}$$

From HHRAP Table B-4-27, all divalent mercury in fish exists or is converted to the methyl mercury (organic) form after uptake into the fish tissue.

$$Hg^{2+} + CH_3^- \rightarrow CH_3Hg^+$$

$$C_{fish_{Total\ MHg}} = C_{fish_{MHg}} + \frac{MW_{MHg}}{MW_{Hg^{2+}}} \cdot C_{fish_{Hg^{2+}}}$$

$$C_{organs_{Total\ MHg}} = C_{organs_{MHg}} + \frac{MW_{MHg}}{MW_{Hg^{2+}}} \cdot C_{organs_{Hg^{2+}}}$$

Where

$C_{fish_{Total\ MHg}}$ = the total concentration of mercury in fish meat (in the form of methyl mercury) (mg/kg)

$C_{organs_{Total\ MHg}}$ = the total concentration of mercury in fish organs (in the form of methyl mercury) (mg/kg)

MW_{MHg} = molecular weight of methyl mercury (215.62 g/mol)

MW_{Hg2+} = molecular weight of divalent mercury (200.59 g/mol)

Other variables (C_{dw}, BAF) are as defined above, but are specific to methyl mercury (MHg) and divalent mercury (Hg^{2+}).

For dioxins, furans, and PCBs, fish concentrations will be estimated from sediment concentrations and *BSAF* values using the following equation:

$$C_{fish} = \frac{C_{sed} \cdot f_{lipid} \cdot BSAF_{fish}}{OC_{sed}} \qquad \text{(HHRAP Table B-4-28)}$$

where:

C_{fish} = concentration of COPC in fish (mg/kg).

C_{sed} = COPC concentration in bed sediment (mg/kg) calculated in Table B-4-25 of the HHRAP.

f_{lipid} = fish lipid content (unitless). The recommended default value of 0.07 (EPA 2005a) is used for f_{lipid} (see Table 7-9).

$BSAF_{fish}$ = biota-to-sediment accumulation factor (unitless) for fish. $BSAF_{fish}$ is COPC-specific and is shown in Supplement 4.

OC_{sed} = fraction of organic carbon in bottom sediment (unitless). The recommended default value of 0.04 (EPA 2005a) is used for OC_{sed} (see Table 7-9).

Fish Uptake Factors for Human Health Risk Assessment

In order to estimate fish concentrations from surface water or sediment concentrations, uptake factors are needed. As discussed in the HHRAP (EPA 2005a), three types of uptake factors are used:

- Bioconcentration factors (*BCF*s)
- Bioaccumulation factors (*BAF*s)
- Biota-sediment accumulation factors (*BSAF*s)

Per the HHRAP, for compounds with log K_{ow} less than 4.0, *BCF*s are used to estimate fish concentrations from surface water concentrations. For COPCs with log K_{ow} greater than 4.0, except for extremely hydrophobic compounds (such as, dioxins, furans, and PCBs), *BAF*s are used to estimate fish concentrations from surface water concentrations. Since extremely hydrophobic compounds have a high tendency to bioaccumulate, they are expected to be sorbed to the bed sediments more than being associated with the water phase. Therefore, *BSAF*s are used to estimate fish concentrations from sediment concentrations for dioxins, furans, and PCBs.

The first source of values for *BCF*s, *BAF*s, and *BSAF*s is the HHRAP (EPA 2005a). For values not available in the HHRAP, a literature search (including the SLERAP [EPA 1999b]) was conducted. For values not available in literature, the approaches shown below were used to estimate fish uptake factors (*BCF*s, *BAF*s, and *BSAF*s). The final uptake factors collected or calculated from these sources are provided in Supplement 4. Where organ-specific *BCF*s, *BAF*s, and *BSAF*s were available, they were used to determine fish organ concentrations for use in the assessment of tribal exposures as applicable.

For organic COPCs where published *BCF*s are not available and where log K_{ow} is less than 4.0, *BCF*s are calculated using the following equations from the HHRAP (EPA 2005a):

Log K_{ow} value	Equation	HHRAP equation number
Nonionic species		
< 1	log BCF = 0.50	A-2-27
1 to 7	log BCF = 0.77 log K_{ow} - 0.70 + Σ correction factors	A-2-28
7 to 10.5	log BCF = -1.37 log K_{ow} + 14.4 + Σ correction factors	A-2-29
> 10.5	log BCF = 0.50	A-2-30
Ionic species (carboxylic acids, sulfonic acids and salts, compounds with N of +5 valence)		
< 5	log BCF = 0.50	A-2-31
5 to 6	log BCF = 0.75	A-2-32
6 to 7	log BCF = 1.75	A-2-33
7 to 9	log BCF = 1.00	A-2-34
> 9	log BCF = 0.50	A-2-35

For organic COPCs that are not dioxins, furans, or PCBs, where published *BAF*s are not available and where log K_{ow} is greater than 4.0, the following approach is used to obtain *BAF*s:

1) Calculate an estimate of *BCF* according to the appropriate HHRAP Appendix A equation.
2) Obtain food chain multipliers (*FCM*s) for Trophic Level 3 and 4 fish.
3) Estimate the *BAF* using the following equation, from the SLERAP (EPA 1999b):

$$BAF_{fish} = BCF_{fish} \cdot FCM \qquad \text{(SLERAP [EPA 1999b] Eq. 5-10)}$$

where *FCM* is the largest *FCM* when considering *FCM*s for Trophic Level 3 and 4 fish.

For dioxins (PCDDs) and furans (PCDFs) where published *BSAF*s are not available, the approach shown in the HHRAP Appendix A, Section A2-2.13.4.3, will be used to obtain *BSAF*s:

- For TetraCDDs and TetraCDFs, $BSAF_{fish} = 9.0 \times 10^{-2}$
- For PentaCDDs and PentaCDFs, $BSAF_{fish} = 9.0 \times 10^{-2}$
- For HexaCDDs and HexaCDFs, $BSAF_{fish} = 4.0 \times 10^{-2}$
- For HeptaCDDs and HeptaCDFs, $BSAF_{fish} = 5.0 \times 10^{-3}$
- For OctaCDDs and OctaCDFs, $BSAF_{fish} = 1.0 \times 10^{-4}$

Empirical fish *BSAF* values are available from the US Army Corps of Engineers *BSAF* database (USACE 2010). Conservatively, the maximum reported *BSAF* will be used for the initial assessment. Should a problem be indicated, average *BSAF*s or *BSAF*s more appropriate to the fish consumed by humans will be used to assess potential risks.

7.2 Toxicity Assessment

The purpose of the toxicity assessment is to evaluate the potential for COPCs and ROPCs to cause adverse health effects in exposed individuals. Toxic effects have been evaluated extensively by the EPA. This section provides the results of the EPA evaluation of the COPCs and ROPCs that may be emitted by the WTP.

7.2.1 General Toxicity Information and EPA Guidance for COPCs

This section provides the toxicity values that will be used for evaluating COPCs in the PRA and the source/rationale for these values.

7.2.1.1 Chronic Toxicity of COPCs

Chronic toxicity data have generally been obtained from the *Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites* (EPA 2013, as amended). The RSL table is a living document that reflects the current state of the science of toxicology and risk assessment, with case-by-case exceptions as approved by Ecology.

When toxicity values for a chemical are not available from the RSLs, the use of a surrogate value may be necessary. This process involves applying a toxicity value established for one chemical to another chemical for which no value has been established. The application of surrogate values is based on similarities in structure, mechanism of action, and toxicity. Surrogate values for the SLRA are identified by Ecology and EPA Region 10, in consultation with National Center for Environmental Assessment (NCEA) (CCN 064330, CCN 063814, CCN 063802, CCN 063817, CCN 063818, CCN 063812, and CCN 063803).

Chronic toxicity values from these sources are provided in Supplement 4 and described below. Supplement 4 provides the toxicity value, its source, and whether the value has been extrapolated from another exposure pathway (i.e., oral to dermal). The same approach will be used for the toxicity assessment in both the PRA and FRA. Any new toxicity values that become available prior to development of the FRA will be incorporated in the final assessment.

Chronic Noncarcinogenic Toxicity of COPCs

Oral noncarcinogenic effects of COPCs will be evaluated by comparing a calculated intake or dose with an acceptable daily intake criterion (referred to as the *reference dose* [*RfD*]) established by EPA (1997b, 2004). The effects due to inhalation of noncarcinogenic of COPCs will be evaluated by comparing a calculated exposure concentration with an inhalation reference value (referred to as the reference concentration [*RfC*]).

It is widely accepted that most biological effects of chemicals occur only after a threshold dose is exceeded (Klaassen et al. 1996). For purposes of establishing noncarcinogenic health criteria, this threshold dose is usually estimated from the no observed adverse effect level (*NOAEL*) or lowest observed adverse effect level (*LOAEL*) determined from animal or human studies. The *NOAEL* is defined as the exposure level at which no statistically or biologically significant increases are present in the frequency or severity of adverse effects (EPA 1989). The *LOAEL* is the lowest exposure level at which there are statistically or biologically significant increases in frequency or severity of adverse effects (EPA 1989). The *LOAEL* or *NOAEL* from the most sensitive animal or human study is used by the EPA

to establish long-term health criteria. An *RfD* is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of the dose of a chemical (expressed in mg/kg·day) that is likely to be without an appreciable risk of deleterious effects during a lifetime (EPA 1989). Similarly, a reference concentration (*RfC*) represents the concentration of a chemical in air (expressed as mg/m^3) that is likely to be without an appreciable risk of deleterious effects during a lifetime (EPA 1989). When deriving *RfD*s or *RfC*s, a *NOAEL* value is used preferentially over a *LOAEL* value if both are available from the key study. EPA derives *RfD*s and *RfC*s by applying uncertainty factors to the *NOAEL* or *LOAEL* value to provide a margin of safety. The equation for deriving an *RfD* or *RfC* is shown below:

$$RfD \text{ or } RfC = (NOAEL \text{ or } LOAEL)/(UF \times MF) \qquad \text{(EPA 1989, Sect. 7.7.2, and EPA 2009, Eq. 5)}$$

where:

RfD	=	reference dose (mg/kg·day)
RfC	=	reference concentration (mg/m^3)
NOAEL	=	no observed adverse effect level (mg/kg·day or mg/m^3)
LOAEL	=	lowest observed adverse effect level (mg/kg·day or mg/m^3)
UF	=	uncertainty factor (unitless)
MF	=	modifying factor (unitless)

Uncertainty factors can range from 1 to 10,000 and may include a factor of up to 10 to account for each of the following:

- Variation in sensitivity within human populations
- Extrapolation of effects observed in animals to humans
- Extrapolation from less-than-lifetime exposures in the critical study to lifetime exposures
- Extrapolation from a *LOAEL* to a *NOAEL*, if necessary

In some cases a modifying factor, usually ranging from 1 to 10 (or <1 for most essential nutrients [EPA 1989]), also is applied to the *NOAEL* or *LOAEL*. This value reflects a qualitative professional assessment of additional uncertainties in the critical study and in the entire database for the chemical not explicitly addressed by the above uncertainty factors (EPA 1989). The EPA establishes *RfD*s and *RfC*s for evaluating both subchronic (less than 7 years) and chronic (7 years or more) exposures. Chronic *RfD*s will be used to evaluate all exposure scenarios, except the acute scenario, and are presented in Supplement 4.

Carcinogenic Toxicity of COPCs

The health risk from exposure to a carcinogen is defined in terms of probability. This probability is defined as the likelihood of a carcinogenic response in an individual that receives a given dose of a particular compound. Oral cancer risks are estimated using chemical-specific cancer slope factors (*CSF*s). For chemicals, the *CSF* is defined as a plausible upper-bound estimate of the probability of a response (e.g., cancer) per unit intake of a chemical over a lifetime (EPA 1989). A *CSF* is provided for potentially carcinogenic COPCs in Supplement 4.

In addition to the quantitative *CSF*, a qualitative weight-of-evidence classification is assigned to characterize the quality and quantity of data used to evaluate the potential carcinogenicity of chemicals.

These classifications are provided in the Integrated Risk Information System (IRIS). As defined by EPA (1989), chemicals used to be assigned to any of six weight-of-evidence groups:

- Group A - Human carcinogen (sufficient evidence of carcinogenicity in humans)
- Group B1 - Probable human carcinogen (limited evidence of carcinogenicity in humans)
- Group B2 - Probable human carcinogen (sufficient evidence of carcinogenicity in animals, with inadequate or lack of evidence in humans)
- Group C - Possible human carcinogen (limited evidence of carcinogenicity in animals, or lack of human data)
- Group D - Not classifiable as to human carcinogenicity (inadequate or no evidence)
- Group E - Evidence of noncarcinogenicity for humans (no evidence of carcinogenicity in adequate studies)

Consistent with EPA guidance (EPA 1989), chemicals assigned a weight-of-evidence classification of A, B1, or B2 are quantitatively evaluated for carcinogenic dose-response. All Group C carcinogens are also quantitatively evaluated for carcinogenic effects.

As indicated in the *Guidelines for Carcinogen Risk Assessment* (2005c), EPA has moved away from this approach for carcinogen assessments. Early-life (childhood) exposure to carcinogens has also been evaluated by EPA as reflected in *Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure* (2005d). In addition to the weight-of-evidence classifications published in IRIS, more recent EPA guidance (2005c) recommends the use of qualitative standard descriptors as part of the narrative to express conclusions about the weight of evidence for human carcinogenic potential. The EPA (2005c) defines five descriptors, which are roughly equivalent to the weight-of-evidence classifications provided by IRIS. More than one descriptor may be applicable for a single chemical (e.g., if it is likely to be carcinogenic by one route of exposure but not by others). The five descriptors are:

1 Carcinogenic to humans
2 Likely to be carcinogenic to humans
3 Suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential
4 Data are inadequate for an assessment of human carcinogenic potential
5 Not likely to be carcinogenic to humans

The descriptors will be used in the PRA and the FRA as part of the risk characterization presentations for specific chemicals that may be risk drivers.

The EPA sometimes reports cancer potency as a unit risk factor (*URF*) based on chemical concentration in air or drinking water. In general, the drinking-water unit risk is derived by converting a slope factor from units of mg/kg·day to units of g/L, whereas an inhalation unit risk is developed directly from a dose response analysis using equivalent human concentrations already expressed in units of g/m^3 (EPA 2005c, Section 3.3.3). Oral *CSF*s are calculated from the corresponding *URF* values, when necessary, using the following equation:

$$CSF_{oral} = (URF_{oral} \times BW \times CF) / CR_{dw} \qquad \text{(EPA 1989, Sect. 7.3.3, modified)}$$

where:

CSF_{oral} = chemical-specific oral *CSF* $(mg/kg \cdot day)^{-1}$
URF_{oral} = chemical-specific drinking water unit risk factor (*URF*) $(\mu g/L)^{-1}$
BW = default body weight (70 kg)
CF = conversion factor (1000 µg/mg)
CR_{dw} = default drinking water consumption rate (2 L/day)

Expression of the drinking water *URF* in terms of dose is necessary to evaluate cancer risk associated with exposure media other than drinking water (such as soil). The EPA recognizes the need for expressing oral toxicity values in terms of dose (mg/kg·day) for risk assessment purposes and acknowledges that, in many cases, this conversion does not add significant uncertainty to the risk assessment process (EPA 1997b).

The interaction of the inhaled contaminant with the respiratory tract is affected by factors such as species-specific relationships of exposure concentrations (*EC*s) to deposited/delivered doses and physiochemical characteristics of the inhaled contaminant. The EPA (2009) therefore recommends that when estimating risk via inhalation, risk assessors should use the concentration of the chemical in air as the exposure metric (e.g., mg/m^3), rather than inhalation intake of a contaminant in air based on inhalation rate and body weight (e.g., mg/kg·day). Consequently, the equivalent derivation of an inhalation *CSF* from the *URF* is not generally performed unless the respiratory deposition and absorption characteristics of the constituent are known (refer to Section 7.5.2).

Chemicals that have been determined to cause cancer by a mutagenic mode of action are thought to pose a higher risk during early life and it is possible that exposures to such chemicals in early-life may result in higher lifetime cancer risks than a comparable duration adult exposure. If a mutagenic mode of action for carcinogenicity of a constituent has been determined by EPA, and a linear low-dose extrapolation performed, one of the following generally pertains:

1. If chemical-specific data on susceptibility from early-life exposures were available for derivation of *CSF*s, those slope factors are used for risk characterization, and age dependent adjustment factors (*ADAF*s) are not applied.
2. If chemical-specific data on susceptibility from early-life exposures were not available, the *ADAF*s are applied in calculating or estimating risks associated with early-life exposures (EPA 2005d).

If the latter case applies, the *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (EPA 2005d) recommends default *ADAF*s be applied in risk assessments for the assessment of chemicals that cause cancer by a mutagenic mode of action as detailed in Section 7.2.1.4.

Chronic Dermal Toxicity of COPCs

Oral *RfD*s and *CSF*s are currently available for many of the COPCs. Dermal *RfD*s and *CSF*s are estimated for COPCs from oral toxicity values using chemical-specific gastrointestinal absorption factors (*GAF*s) to calculate total absorbed dose. This conversion is necessary because most oral *RfD*s and *CSF*s are expressed as the amount of chemical *administered* per time and body weight; however, dermal exposure is expressed as an *absorbed* dose. Dermal toxicity factors are calculated from oral toxicity factors as shown below (EPA 2004):

$$RfD_{dermal} = RfD_{oral} \times GAF \quad \text{(EPA 2004, Eq. 4.3)}$$

$$CSF_{dermal} = CSF_{oral} \div GAF \quad \text{(EPA 2004, Eq. 4.2)}$$

Chemical-specific *GAF* values are used when available. Not all COPCs have chemical-specific *GAF* values. When quantitative data were not available, default *GAF* values of 0.8 for VOCs, 0.5 for SVOCs, and 0.2 for inorganics are used (Ecology 2002). The *GAF* values are provided in Supplement 4 along with the resulting dermal *RfD* and *CSF*s.

7.2.1.2 Acute Toxicity of COPCs

Acute effects from direct inhalation of airborne COPCs (vapor and particulate) are evaluated by comparison of modeled one-hour maximum air concentrations to AIEC. The AIEC values for COPCs were selected based on the following hierarchy:

1 **Values from the NCEA** (as provided by EPA Region 10).

2 **Acute reference exposure levels (ARELs) from California EPA**. The AREL is an exposure that is not likely to cause adverse effects in a human population, including sensitive subgroups, exposed to that concentration for one hour on an intermittent basis. The ARELs are based on the most sensitive, relevant, adverse health effect reported in the medical and toxicological literature. The ARELs are designed to protect the most sensitive individuals in the population by the inclusion of margins of safety. Since margins of safety are incorporated to address data gaps and uncertainties, exceeding the AREL does not automatically indicate an adverse health impact.

3 **Acute exposure guideline levels (AEGL-1)**. If an AEGL-1 value is not available but an AEGL-2 value is available, the AEGL-2 value will be used unless a more conservative value is available from one of the other sources in the hierarchy. The one-hour AEGLs are used. The AEGL-1 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. The AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects, or an impaired ability to escape.

   Airborne concentrations below the AEGL-1 represent exposure levels that could produce mild and progressively increasing odor, taste, and sensory irritation, or certain non-symptomatic, non-sensory effects. With increasing airborne concentrations above each AEGL level, there is a progressive increase in the likelihood of occurrence and the severity of effects described for each corresponding AEGL level. Although the AEGL values represent threshold levels for the general public, including sensitive subpopulations, it is recognized that certain individuals, subject to unique or idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL level. **Note**: This description is from "National Advisory Committee for Acute Exposure Guideline Levels (AEGLs) for Hazardous Substances; Proposed AEGL Values," *Federal Register*, 18 July 2003 (Volume 68, Number 138), pages 42710-42726.

4 **Emergency response planning guidelines (ERPG-1)**. The ERPG-1 are the maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor. Safety factors are not included.

5 **Temporary emergency exposure limits (TEEL-1).** The TEELs are temporary levels of concern similar to ERPGs, and defined by the US Department of Energy for use when ERPGs are not available. As with ERPGs, safety factors are not included.

The AIEC values selected using this hierarchy are provided in Supplement 4 along with their basis. Only one NCEA provisional value (for PCBs) is used. The AELs from California EPA include potential effects of intermittent acute exposures. AEGL-1, AEGL-2, and ERPG-1 values assume one-time-only acute exposures and are available in units of parts per million (ppm). Some TEELs are provided in ppm and some in mg/m^3. Values are provided in their original units, along with conversion factors, in Supplement 4. The use of values obtained other than NCEA values or California EPA AELs will be discussed as a nonconservative uncertainty in the uncertainty section of the risk assessment.

7.2.1.3 Toxicity of COPCs to Nursing Infant

Potential infant exposures to PCDD/PCDFs and coplanar PCBs in human breast milk will be evaluated in the SLRA. The interpretation of infant exposure is limited by the lack of infant dose-response data. The EPA (2005a) recommends evaluating infant exposures to dioxins in breast milk by comparing a site-specific calculated dose to the infant (ADD_{inf}) to a background dose to the infant.

A background infant *ADD* of 93 pg/kg·day of PCDD/PCDFs and co-planar, dioxin-like PCBs in breast milk as 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalents (TEQ), has been calculated by the EPA based on an average background 2,3,7,8-TCDD TEQ concentration of 25 parts per trillion (ppt) measured in breast milk. The 25 ppt 2,3,7,8-TCDD TEQ is the sum of the average breast milk concentration of 18 ppt TEQ from PCDD/PCDFs and 7-ppt TEQ from co-planar, dioxin-like PCBs. After normalization for infant body weight, this breast milk concentration of 25 ppt TEQ results in an average, background intake for the infant, $ADI_{b\text{-}inf}$, of 93 picograms per kilogram per day (pg/kg·day) of 2,3,7,8-TCDD TEQ (EPA 2005a, Section 2.3.10.2). Based on the national average background exposure level of 60 pg TEQ/kg/day of PCDD/PCDFs for nursing infants reported by EPA (2005a), 33 pg TEQ/kg/day is attributable to background exposure levels of co-planar, dioxin-like PCBs.

This background approach will also be used for evaluating potential risks to the nursing infant for exposure to "dioxin-like" coplanar PCBs. The estimated dose (as 2,3,7,8-TCDD equivalents) of coplanar PCBs will be compared to a background infant dose of 33 pg TEQ/kg·day. In addition to evaluating dioxin and PCB exposures separately, a total infant dose of dioxin-like compounds (PCDDs/PCDFs and coplanar PCBs expressed as 2,3,7,8-TCDD equivalents) will be calculated and compared to a total background dose of dioxin-like compounds of 93 pg TEQ/kg·day. This background dose may overestimate current exposures because dioxin exposures have been decreasing. The source of this value and potential range of background doses will be discussed further in the uncertainty assessment of the PRA report.

This approach is based on the assumption that, if the estimated dose to a nursing infant from site-related dioxins is below the nationwide background dose of dioxins to nursing infants, the site-related risk of cancer or noncancer effects is not significant.

In discussing infant exposure to background concentrations of dioxins, EPA (2003) notes that "breast-feeding infants have higher intakes of dioxin and related compounds for a short but developmentally important part of their lives. However, the benefits of breast feeding are widely recognized to outweigh the risks."

Although background intakes of dioxins by nursing infants (60 pg TEQ/kg·day, EPA 2005a) are relatively high compared to adult intakes (1 pg TEQ/kg·day, EPA 2005a), the body burden of nursing infants is only about two times that of adults, and the contribution of infant exposure to eventual adult body burden is small. The reduced body burden in nursing infants (relative to intake) may be due to the rapid growth of the infant and a faster elimination/excretion rate in infants.

Transplacental transfer of dioxins from the mother to the fetus may also be a significant source of exposure. Dioxins may produce a broad range of effects in experimental animals exposed in-utero, and limited epidemiological studies have been conducted (EPA 2005c). Potential effects (cancer or noncancer, including developmental effects) of prenatal exposures are not included in the quantitative evaluation of risk.

There is currently no consensus regarding the most appropriate single approach to quantitatively evaluate potential risks associated with exposure to dioxin-like compounds by nursing infants. Alternative approaches to the two methods described above (i.e., comparison to background and lifetime risk) include calculating infant risks using (1) the infant ADD calculated in accordance with HHRAP, Table C-3-2, and (2) the lifetime risk calculated in accordance with *Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure to Carcinogens* (EPA 2005d). These alternative methods will be presented in the uncertainty assessment of the PRA report.

7.2.1.4 Toxicity of Mutagens

Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure to Carcinogens (EPA 2005d) provides draft EPA guidance for evaluating early-life exposures to carcinogens. This guidance recommends that when developing quantitative estimates of cancer risk, age-specific values for both exposure and toxicity/potency should be integrated where such data are available and appropriate, specifically:

- Early life exposures to carcinogens may have a larger or smaller impact on lifetime cancer risk than later exposures, even if the total lifetime exposure is the same.
- Exposures near the end of life may have little effect on lifetime cancer risk.

EPA 2005d recommends calculating a combined lifetime risk rather than separate infant, child, and adult risks with specific adjustments based upon increased susceptibility of younger receptor for mutagenic compounds. If the incremental lifetime cancer risk (ILCR) associated with mutagenic COPCs[8] exceeds 10^{-7} then the risk due to exposure to these COPCs will be further assessed with consideration for age adjustment factors as described below. For mutagenic chemicals, early life exposures have a larger impact than later exposures on lifetime risk. This impact can be quantified using an age dependent adjustment factor (*ADAF*) to make the following adjustments (EPA 2005d):

- For exposures before 2 years of age, a 10-fold adjustment (*ADAF* = 10)
- For exposures between 2 and 16 years of age, a 3-fold adjustment (*ADAF* = 3)
- For exposures after 16 years of age, no adjustment (*ADAF* = 1)

[8] Mutagenic COPCs are those that are published in Table 1b of EPA 2005d or EPA the RSL Tables (EPA 2013, or most recent update) , and are subject to periodic updating by EPA. Such mutagenic COPCs are identified in Supplement 4.

However, for this risk assessment, the division between infant and children exposures, and children and adult exposures does not occur at ages 2 and 16. Depending on the receptor, the nursing infant is presumed to be exposed (to breast milk) from ages 0 to age 1 or 2. Childhood exposures are assumed to occur over the first 6 years of life, and adult exposures are considered to apply to all receptors after age 6. A sensitivity analysis on exposure assumptions for the *ADAF* age bins indicated that it there is little difference in the outcome if they are not changed from the standard assumptions, but they should be broken into the following: age 0 to <2 yr (*ADAF*=10), age 2 to <6 yr (*ADAF*=3), age 6 to <16 yr (*ADAF*=3), and older than age 16 (*ADAF*=1). The infant exposure takes place over 1 or 2 years (depending on the receptor), the child is exposed from age 2 (or 3) through age 6, and the adult is exposed from age 7 through age 70. The EPA addresses the discrepancy between the age division common to risk assessments and the application of *ADAF*s in the electronic *Handbook for Implementing the Supplemental Cancer Guidance at Waste and Cleanup Sites* (EPA 2012b).

The EPA *ADAF*s are prorated according the age divisions to derive an *ADAF* appropriate to the receptors in this RAWP by modifying the exposure duration (*ED*) according to the age bins. The corresponding cancer risk for each age interval "i" takes the following form.

$$Risk_i = C\frac{CR_i \cdot EF_i \cdot ED_i}{BW_i \cdot AT_C} \cdot CSF \cdot ADAF_i \qquad \text{(EPA 2012b)}$$

where:

- C = concentration of the chemical in the contaminated environmental medium (soil or water) to which the person is exposed (mg/kg or mg/L).
- CR_i = consumption or intake rate of the contaminated environmental medium for age bin *i* (mg/day or L/day).
- BW_i = body weight of the exposed person for age bin *i* (kg).
- EF_i = exposure frequency for age bin *i* (days/year)
- ED_i = exposure duration for age bin *i* (years)
- AT_C = averaging time (yr)
- CSF = cancer slope factor $(mg/kg \cdot day)^{-1}$
- $ADAF_i$ = age dependent adjustment factor for cancer slope factor for mutagenic chemicals for age bin *i* (unitless)

The risk assessment age divisions are shown with the *ADAF* age intervals below (EPA 2012b):

Receptor	Exposure Duration (*ED*, years)	Age (years)	Exposure Factors	Exposure Duration (ED_i, years)	ADAF (unitless)
Child	6	0 to <2	Child	2	10
		2 to <6	Child	4	3
Adult	varies, 30 to 70	6 to <16	Adult	10	3
		≥16	Adult	*ED* - 16	1

Total risk to the individual is the sum of the risks across all four age intervals. If exposure occurs across multiple pathways (e.g., ingestion, dermal absorption and inhalation), risks are also summed across pathways.

$$Risk_{0\,to\,<2} = C\frac{CR_{child}\cdot EF_{child}\cdot 2yr}{BW_{child}\cdot AT_C}\cdot CSF\cdot 10 \qquad Risk_{2\,to\,<6} = C\frac{CR_{child}\cdot EF_{child}\cdot 4yr}{BW_{child}\cdot AT_C}\cdot CSF\cdot 3$$

$$Risk_{6\,to\,<16} = C\frac{CR_{adult}\cdot EF_{adult}\cdot 10yr}{BW_{adult}\cdot AT_C}\cdot CSF\cdot 3 \qquad Risk_{\geq 16} = C\frac{CR_{adult}\cdot EF_{adult}\cdot (ED-16)yr}{BW_{adult}\cdot AT_C}\cdot CSF\cdot 1$$

and

$$Risk_{lifetime} = Risk_{0\,to\,<2} + Risk_{2\,to\,<6} + Risk_{6\,to\,<16} + Risk_{\geq 16}$$

The equations above are generalized for intake and the quantity $(C\times CR_i\times EF_i\times ED_i)/(BW_i\times AT_C)$ differs from the *LADD* shown in Section 7.1.5 by the value used for exposure duration, ED_i. Dermal absorption (which contributes to the *LADD*) and inhalation (which contributes to the *EC*) are also valid pathways. Algebraically, the term $(C\times CR_i\times EF_i\times ED_i)/(BW_i\times AT_C)$ equates to the *LADD* times the ratio of the age interval exposure duration, ED_i, and the receptor's exposure duration, *ED*. The same is true with regard to applying the *ADAF* to inhalation exposures. Accordingly, the equations for exposures can be written as:

ingestion and dermal absorption exposures:

$$Risk_i = LADD\cdot\frac{ED_i}{ED}\cdot CSF\cdot ADAF_i$$

and for inhalation exposures:

$$Risk_i = EC\cdot\frac{ED_i}{ED}\cdot URF\cdot ADAF_i$$

where:

- $LADD$ = lifetime average daily for the receptor's total exposure period (mg/kg·day)
- EC = exposure concentration (µg/m^3)
- ED_i = exposure duration for age bin *i* (years)
- ED = exposure duration for the receptor (number of years that the receptor is exposed to the COPC)
- CSF = oral or dermal cancer slope factor, as appropriate (kg·day/mg)
- URF = inhalation unit risk factor (m^3/µg)
- $ADAF_i$ = age dependent adjustment factor for cancer slope factor for mutagenic chemicals for age bin *i* (unitless)

Benzo[a]pyrene is often used as an index chemical when assessing other carcinogenic PAHs as described in the "*Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*" (EPA 1993b). The EPA recommends that when assessing early-life exposure for PAHs using such an approach, the ADAF(s) should be applied to the benzo[a]pyrene slope factor before using relative potency factors to estimate risk from exposure to other PAHs (EPA 2006).

For carcinogens that act by mechanisms other than mutagenicity, early life exposure may have a larger, smaller, or no impact on lifetime cancer risk. This impact would be chemical- or mechanism-specific and cannot be quantified at this time; therefore, no adjustment factor is recommended. The potential impact of exposures near the end of life also cannot be quantified.

Radionuclides are mutagens; however, slope factors for radionuclides sufficiently consider age factors. These adjustment factors will not be used in calculating lifetime risks for nursing infants exposed to ROPCs. The PCDDs/PCDFs and PCBs are not mutagens; therefore, lifetime risk for these compounds will be calculated with no adjustment to the *CSF*.

7.2.2 Toxicity Information and EPA Guidance for Specific COPCs

The toxicity assessments for several COPCs and classes of COPCs with unique toxicity characteristics or methods for assessment are described below.

7.2.2.1 Chromium

Hexavalent chromium (Cr^{+6}) is the most toxic valence state of chromium and has been shown to be a human carcinogen through inhalation. Trivalent chromium (Cr^{+3}) has not been shown to be carcinogenic in either humans or laboratory animals; however, the mechanism of Cr^{+6} carcinogenicity in the lung is believed to be its reduction to Cr^{+3} and its generation of reactive intermediates (Klaassen et al. 1996). While chromium emitted from the melter is not likely to be in the hexavalent form, the PRA will conservatively assume that 100 % of the facility emissions are hexavalent chromium for the carcinogen assessment and 100 % trivalent chromium for the noncarcinogen assessment. For the FRA, the same assumptions will be made unless WTP performance demonstration test data for this compound is available to provide more realistic estimates.

7.2.2.2 Nickel

The EPA (2005a) recommends that nickel be evaluated as an inhalation carcinogen because some forms of nickel, including nickel carbonyl, nickel subsulfide, and nickel refinery dust, are considered to be carcinogens. Nickel emissions from hazardous waste combustion units are emitted as nickel oxide which, by itself, is not considered to be a carcinogen; however, nickel oxides can be reduced to nickel sulfates (some of which are carcinogenic) in the presence of sulfuric acid (EPA 2005a). In addition, nickel oxide is a major component of nickel refinery dust (other major components include nickel subsulfide and nickel sulfide), which is identified as a potential human inhalation carcinogen. The components responsible for the carcinogenicity of nickel refinery dust have not been conclusively established. Therefore, nickel emissions are evaluated as a potential carcinogen through the inhalation pathway using the inhalation *URF* for nickel refinery dust. For exposure pathways other than inhalation, nickel has not been shown to be carcinogenic and will be evaluated as a noncarcinogen using the oral *RfD* for nickel-soluble salts.

7.2.2.3 Particulates

Toxicity values (i.e., *RfC*s and *URF*s) are not available to quantitatively evaluate potential adverse health effects associated with inhaling particulates. Therefore, modeled annual average concentrations of respirable particulates will be compared with the following National Ambient Air Quality Standard (NAAQS) values:

Particle Diameter	NAAQs value[a]
< 10 μm (PM_{10})	50 μg/m^3
< 2.5 μm ($PM_{2.5}$)	15 μg/m^3

[a]Values are for annual average concentrations.

For air modeling purposes, it is assumed that all particulates released from the facility will have a diameter of 1 μm or 2.5 μm; therefore, the $PM_{2.5}$ standard will be used for comparison to predicted air concentrations.

7.2.2.4 Trichloroethylene

Independently of any carcinogenic and/or mutagenic effects, trichloroethylene (TCE) may cause fetal cardiac malformations when a mother is exposed to TCE during a 21-day early gestation window. Region 10 human health toxicologists have determined that, to protect against potential noncancer fetal malformation outcomes, that average exposures over any 21-day period of time not exceed the concentrations in air or other media that are calculated to be protective for this exposure using the *RfD* and *RfC* provided in IRIS (EPA 2012c). If TCE exposures approach levels that would cause concern as discussed in the EPA 2012 memorandum, TCE will be further evaluated to assess its potential to present a risk of fetal cardiac malformations during a short window during early pregnancy as described in the memorandum.

7.2.2.5 Polycyclic Aromatic Hydrocarbons

Potential cancer risks associated with the seven PAHs considered to be carcinogenic by EPA (benzo[a]pyrene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) will be evaluated using a toxicity equivalency approach. This toxicity equivalency approach is based on the CALEPA/CARB 1994 approach cited below, which is endorsed by Ecology in Model Toxics Control Act, WAC 173-340-708(8). Adequate toxicity data are available to determine a *CSF* only for benzo[a]pyrene. A relative potency factor (RPF) is assigned to each of the other six carcinogenic PAHs as compared to benzo[a]pyrene (refer to EPA 2005a, Table 2-8). Using this method, exposure concentrations are converted to equivalent concentrations of benzo[a]pyrene by multiplying the concentration by the appropriate toxicity equivalency factor (*TEF*). This approach results in toxicity equivalent (TEQ) concentrations of each carcinogenic PAH. The *CSF* for benzo[a]pyrene will then be used to evaluate risk from the equivalent concentration of each PAH. The *TEF*s, available from EPA (2005a) and Ecology (WAC 173-340-900), are presented in Supplement 4. This method will be applied to oral, dermal, and inhalation exposure pathways as shown in the generic equations below.

$$LADD_{TEQ} = I_{oral\ or\ dermal} \times TEF_{PAH}$$

$$ILCR_{oral\ or\ dermal} = LADD_{TEQ} \times CSF_{BaP}$$

$$ILCR_{inh} = EC \times TEF_{PAH} \times URF_{BaP}$$

where:

$LADD_{TEQ}$ = toxicity equivalent lifetime average daily dose due to oral (ingestion) or dermal (skin absorption) exposure pathways (mg/kg·day)

$I_{oral\ or\ dermal}$ = intake of the PAH of interest due to oral or dermal exposure pathways (mg/kg·day)

TEF_{PAH} = toxicity equivalency factor associated with the PAH of interest (unitless)

$ILCR_{oral\ or\ dermal}$ = incremental lifetime cancer risk from oral or dermal exposure pathways (unitless)

CSF_{BaP} = Oral or dermal *CSF* for benzo[a]pyrene (kg·day/mg)

$ILCR_{inh}$ = incremental lifetime cancer risk from inhalation pathways (unitless)

EC = exposure concentration of the PAH of interest through inhalation (mg/m^3).

URF = inhalation unit risk factor for benzo[a]pyrene ($m^3/\mu g$)

One limitation to this approach is that it does not measure point-of-action effects, such as skin cancer.

The *TEF*s are available from *Model Toxics Control Act* (MTCA) Part IX (WAC 173-340-900) for additional potentially carcinogenic PAH COPCs not included in EPA guidance (refer to MTCA Tables 708-2 and 708-3). No *RfD* values are available for evaluating noncancer effects for these PAHs. Noncancer-only effects are evaluated for acenaphthene, anthracene, fluorene, naphthalene, and pyrene. These are included with their *RfD*s in Supplement 4 (organic COPCs). If PAHs are predicted to be important emissions from the facility based on their estimated cancer risks, surrogate toxicity values may be considered. Any selection of surrogates would be conducted by Ecology and EPA toxicologists. The WTP will provide Ecology and EPA with a list of PAHs for which surrogate values are needed. The PAHs with Ecology/EPA-provided surrogates will then be included in the quantitative evaluation. The PAHs lacking Ecology/EPA-approved surrogates will be evaluated qualitatively in the uncertainty assessment in the PRA.

7.2.2.6 Polychlorinated Dibenzo-p-dioxins, Polychlorinated Dibenzofurans, and Polychlorinated Biphenyls

The PCDDs, PCDFs, and PCBs are thought to act through a common mechanism of toxicity by binding to a protein known as the arylhydrocarbon receptor (AR) (for review, see Agency for Toxic Substance and Disease Registry [ATSDR] 1997 or World Health Organization [WHO] 1998). The AR-ligand complex is responsible for the activation of genes that have a deleterious effect when they are not under proper regulation by the receptor's hormones. Interaction of dioxins and similar compounds with AR, therefore, can cause immunological, neurological, endocrine, embryotoxic, and many other effects.

The similarity in action of these compounds is thought to result from their structural similarity. Dioxin is composed of two benzene rings joined by two carbon-oxygen-carbon bonds on two adjacent carbons of each benzene ring. Dibenzofurans have two benzene rings joined by a carbon-oxygen-carbon bond and a carbon-carbon bond on two adjacent carbons of each benzene ring. Biphenyls consist of two benzene rings joined by a single carbon-carbon bond. To form the polychlorinated derivatives, chloro groups are attached at various locations, as designated in the names of the compounds. Benzene rings are planar (i.e., flat) in conformation. Because two adjacent carbons on each benzene ring are joined in dioxins and dibenzofurans, both benzene rings are held in the same plane, and the chloro groups are also in that plane. Therefore, these molecules are said to be coplanar. The coplanar structure appears to be essential for interaction with AR. The benzene rings in biphenyl can rotate relative to each other, unless there are added groups that interfere with rotation (such as 2,2′,6,6′-chloro groups, which occupy the carbons immediately on both sides of the carbon-carbon bond joining the rings). The PCB congeners that are able to form a coplanar molecule (and are called *coplanar PCBs*) can interact with AR when they are in that

configuration. Therefore, coplanar PCBs are included among the COPCs with similar action to dioxins and dibenzofurans.

Potential cancer risks associated with PCDDs/PCDFs and coplanar PCBs will be evaluated using the cancer *CSF* for 2,3,7,8-TCDD of 1.0E+06 $(mg/kg \cdot day)^{-1}$ proposed in the *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds* (EPA 2003) at the direction of Ecology and EPA Region 10 (CCN 063809). While the proposed *CSF* has not yet been approved by EPA, it is more conservative than the current *CSF* published in HEAST (1997) and in the HHRAP database, and is widely considered to represent the best available science.

A discussion of risk results using both the 1997 (HEAST) and 2003 (dioxin reassessment) *CSF*s will appear in the uncertainty section of the PRA.

Because these contaminants have a common mechanism of action, it is assumed that their toxicity to biota is additive (WHO 1998, EPA 2005a). That is, the risks from all dioxins, dibenzofurans, and coplanar PCBs will be added.

Polychlorinated Dibenzo-p-dioxins and Polychlorinated Dibenzofurans

The EPA (2005a) recommends evaluating all PCDD/PCDF congeners with chlorine molecules substituted in the 2, 3, 7, and 8 positions as carcinogens. Potential cancer risks associated with these PCDD/PCDFs will be evaluated using a toxicity equivalency approach. This approach assigns a relative toxicity of each of the seventeen 2,3,7,8-substituted PCDDs/PCDFs as compared to 2,3,7,8-TCDD. Using the method, exposure concentrations are converted to equivalent concentrations of 2,3,7,8-TCDD by multiplying the concentration by the appropriate TEF. This conversion results in TEQ concentrations of each congener. The *CSF* for 2,3,7,8-TCDD is then used to evaluate risk from the total TEQ concentration. The most recent TEFs, available from MTCA Part IX (WAC 173-340-900) and EPA (2005a) and provided in Supplement 4, will be used. Equations used to incorporate TEFs are the same as those shown for PAHs, with the exception that 2,3,7,8-TCDD is the toxicity surrogate instead of benzo[a]pyrene.

Polychlorinated Biphenyls

Coplanar PCBs and PCDDs/PCDFs are similar structurally and may act through common mechanisms of toxicity. The EPA (2005a) and Ecology have implemented the use of dioxin TEFs for coplanar, dioxin-like PCBs. Using this approach, exposure concentrations of coplanar PCBs are converted to equivalent concentrations of 2,3,7,8-TCDD by multiplying the concentration by the appropriate TEF. The *CSF* for 2,3,7,8-TCDD is used to evaluate risk from the total TEQ concentration. Potential cancer risks associated with coplanar PCB emissions will be estimated using TEFs available from the HHRAP and listed in Supplement 4. Note that TEFs are available for 12 coplanar PCBs (HHRAP Table 2-5 and MTCA Table 708-4).

The estimated dose of coplanar PCBs, expressed as 2,3,7,8-TCDD equivalents, will be added to the total estimated dose of dioxins and used to estimate total risk from "dioxin-like" compounds in addition to evaluating coplanar PCB dose separately.

Other (noncoplanar) PCBs will be evaluated using the *CSF* for PCBs shown in Supplement 4. EPA (2005a) recommends different *CSF*s for different exposure routes and chlorine contents. The most conservative *CSF* (i.e., *CSF* from the high-risk persistence tier) is presented in Supplement 4 and will be used for the PRA.

Noncancer effects of PCBs will be evaluated using the *RfD* for Aroclor-1254.

7.2.3 Surrogate Values

When chemical-specific toxicity values for a chemical are not available, the use of a surrogate value may be necessary. This process involves applying a toxicity value established for one chemical to another chemical for which no value has been established. The application of surrogate values is based on similarities in structure, mechanism of action, and toxicity. The following surrogate values for the SLRA have been identified by Ecology and EPA Region 10 (Table 7-10).

The use of these surrogates is reflected in the toxicity values and physical/chemical property values presented in this RAWP. In the absence of toxicity data for both the original COPC and the surrogate chemical, physical/chemical data is provided. A periodic review of available information will be performed and surrogate values will be abandoned in favor of actual peer-reviewed constituent values as they are made available (e.g., toxicity values will be updated as they become available in as described in Section 7.2.1.1).

7.2.4 Toxicity Information and EPA Guidance for ROPCs

This section provides the toxicity values that will be used for evaluating ROPCs and the source/rationale for these values.

7.2.4.1 Chronic Noncarcinogenic Toxicity of ROPCs

The ROPCs are not evaluated for noncarcinogenic effects; however, the stable form of ROPCs with noncarcinogenic effects is evaluated as COPCs. For example, the potential cancer effect of Sr-90 is evaluated as an ROPC while the potential noncancer effects of stable strontium are evaluated as a COPC. The list of inorganic COPCs includes the stable form of 11 ROPCs (antimony, barium, cadmium, cobalt, nickel, selenium, strontium, tin, uranium, yttrium, and zirconium).

7.2.4.2 Carcinogenic Toxicity of ROPCs

Ionizing radiation, and therefore all ROPCs, is considered to be a Group A carcinogen. Cancer risk from exposure to ROPCs through ingestion, inhalation, and external exposure to radionuclides in soil is estimated using a *CSF*. Ingestion and inhalation *CSF*s are central estimates from a linear model of the age-averaged, lifetime radiation cancer incidence risk per unit of activity inhaled or ingested, and are expressed in units of risk/pCi (i.e., pCi^{-1}). Ingestion *CSF*s are taken from the *Health Effects Assessment Summary Tables (HEAST) 2001 Update* (EPA 2001) and are tabulated separately for ingestion of tap water, dietary intakes, and incidental soil ingestion. Inhalation *CSF*s (EPA 2001) are provided separately for inhalation of particulates and vapors or gas.

For external exposure to radionuclides in soil, *CSF*s are central estimates of lifetime radiation cancer risk for each year of exposure to external radiation from photon-emitting radionuclides distributed uniformly in a thick layer of soil. These *CSF*s are expressed as risk/yr per pCi/gram soil (i.e., $[pCi\text{-}yr/g]^{-1}$). The *CSF*s provided for external exposure in HEAST (EPA 2001) are derived from risk coefficients listed in *Federal Guidance Report No. 13* (FGR No. 13) (EPA 1999c) that assume an infinite depth of contaminated soil. For the WTP, however, it is expected that ROPCs will be deposited on the surface and will be uniformly distributed over the top 2 cm of the soil and not to an infinite depth (EPA 2005a). FGR No. 12 (EPA 1993) also provides dose coefficients for a soil depth of 1 cm and 5 cm. The ROPC

contamination level in untilled soil is based on an assumed contamination depth of 2 cm (refer to Section 6.2). For conservatism, dose coefficients for a soil depth of 5 cm are preferred over using 1 cm dose coefficients or straight line extrapolation between the 1 and 5 cm dose coefficients. The HEAST *CSF*s are, therefore, adjusted using dose coefficients provided in FGR No. 12 (EPA 1993), assuming that risk coefficients (and *CSF*s) scale proportionally with dose coefficients and depth. Using this approach, adjustments to HEAST factors are made using the following equation (CCN 064328):

$$CSF_{adj} = CSF_{HEAST} \times (DC_5 \div DC_{inf}) \qquad \text{(Equation 7-9)}$$

where:

CSF_{adj} = adjusted cancer slope factor for external exposure to radionuclides in soil
CSF_{HEAST} = HEAST factor for an infinite depth
DC_5 = FGR No. 12 (Table III.5) dose coefficient for 5 cm depth
DC_{inf} = FGR No. 12 (Table III.7) dose coefficient for infinite depth

The resulting depth-corrected *CSF*s are provided in Supplement 4.

Cancer risk (morbidity) from external exposure to ionizing radiation in air is evaluated using a cancer risk factor (*RF*) expressed in units of $(\text{Bq-secs/m}^3)^{-1}$. The *RF*s are obtained from FGR No. 13 (EPA 1999c) and are provided in Supplement 4.

Some ROPCs are given the suffix "+D" to indicate that cancer risk estimates using these *CSF*s include contributions to toxicity from short-lived decay products. For example, the +D slope factor for Sb-125 includes the contribution of Te-125m, which is assumed to be in equilibrium with the parent. Risks are calculated using these +D *CSF*s. Because the +D *CSF*s for Sr-90 and Cs-137 include the contributions from their short-lived decay products (Y-90 and Ba-137m), separate risks are not calculated for these decay products (Y-90 and Ba-137m). Quantifying separate cancer risks for Y-90 and Ba-137m, in addition to using +D slope factors for Sr-90 and Cs-137, would result in double counting the toxicity of these two ROPCs.

7.2.4.3 Chronic Dermal Toxicity of ROPCs

Dermal absorption of ROPCs will be evaluated for tritium. The internal dose from immersion in a plume of tritiated water vapor is approximately 50 % from inhalation and 50 % from dermal absorption (Till and Meyer, 1983); therefore, for all receptors, the dermal absorption of tritium will be accounted for in the exposure assessment by multiplying the inhalation dose for this ROPC by 2. Dermal absorption of other ROPCs will not be evaluated because this pathway is considered to be insignificant compared to inhalation for all ROPCs except tritium (See Appendix B for further discussion).

7.2.4.4 Acute Toxicity of ROPCs

Acute effects from a one-hour exposure to ROPCs will be estimated based on a total acute dose limit of 0.1 rem. Appendix B provides a review of the literature that establishes the basis for defining a LOAEL for radionuclides. Based on this literature review, the lowest dose where clinically significant nonstochastic effects (i.e., the acute effects of radiation) have been observed is approximately 10 rem. Applying the California EPA methodology from *The Determination of Acute Reference Exposure Levels for Airborne Toxicants* (CalEPA 1999), a default uncertainty factor of 10 is applied to convert this

LOAEL to a NOAEL of 1 rem. The acute dose limit is then estimated by applying a second default uncertainty factor of 10 to account for intraspecies variability to provide protection to sensitive subpopulations. For radiation effects, children represent a sensitive subpopulation. This acute dose limit applies to a single exposure and does not account for intermittent exposures. This approach is very conservative. Unless 5 rem to 25 rem are delivered in a very acute exposure, there would be no adverse effect; by using 0.1 rem, there would not be any anticipated effects at this level. It must be noted that the one-hour radionuclide exposure is not comparable to the one-hour chemical exposures, and 0.1 rem is not an acute criterion.

For each of the ROPCs, acute radionuclide exposure criteria (*AREC*) corresponding to an acute dose of 0.1 rem were calculated as described below. The calculated *AREC*s include two exposure pathways associated with submergence in a cloud of particulate and vapor phase radionuclides: external gamma exposure and inhalation. The following equations were used to calculate *AREC*s for these two pathways:

External Gamma Exposure:

$$AREC_E = DL / (CDE \times ET \times CF_1) \qquad \text{(Equation 7-10)}$$

Inhalation:

$$AREC_I = DL / (CDE \times BR \times ET \times CF_1 \times CF_2) \qquad \text{(Equation 7-11)}$$

Total:

$$AREC_R = \frac{1}{\frac{1}{AREC_E} + \frac{1}{AREC_I}} \qquad \text{(Equation 7-12)}$$

where:

$AREC_E$ = acute radionuclide exposure criteria for external gamma ($\mu Ci/cm^3$)
$AREC_I$ = acute radionuclide exposure criteria for inhalation ($\mu Ci/cm^3$)
$AREC_R$ = total acute radionuclide exposure criteria ($\mu Ci/cm^3$)
DL = dose limit of 0.1 rem (100 mrem)
CDE = committed dose equivalent for radionuclide i ($Sv\text{-}m^3/Bq\text{-}s$ for external gamma; Sv/Bq for inhalation)
CF_1 = conversion factor $\left(10^5 \frac{\text{mrem}}{\text{Sv}} \cdot 0.037 \frac{\text{Bq}}{\text{Ci}} \cdot 10^6 \frac{\text{Ci}}{\mu\text{Ci}} \cdot 10^6 \frac{\text{cm}^3}{\text{m}^3}\right)$
ET = acute exposure time (1 hr)
CF_2 = conversion factor (3600 s/hr)
BR = breathing rate of standard man ($1.2\ m^3/hr$)

The ROPC decay products are represented in the calculation based on their respective decay probabilities. Parent radionuclides are given the "+D" designation to indicate that decay products are considered. Supplement 4 lists the parent and decay products included in the calculations. The following equation

was used to calculate the committed dose equivalent *(CDE)* for the combination of a parent and decay product radionuclides:

$$CDE{+}D = \Sigma\, CDE_i \times f_i \qquad \text{(Equation 7-13)}$$

where:

$CDE{+}D$ = committed dose equivalent for radionuclide *i* and its daughter products
CDE_i = committed dose equivalent for radionuclide *i*
f_i = decay probability of radionuclide *i*

The calculated ARECs shown result in a dose of 0.1 rem from each of the 46 ROPCs; therefore, when combined for all 46 ROPCs, these concentrations would result in a total dose of 4.4 rem. These concentrations are adjusted to ensure that the overall dose from all 46 ROPCs will not exceed 0.1 rem for an acute exposure of one hour, as shown below:

$$AREC_M = AREC_R \div 44$$

where:

$AREC_M$ = acute radionuclide exposure criteria for ROPC *i* corrected for the presence of multiple ROPCs ($\mu Ci/cm^3$)
$AREC_R$ = acute radionuclide exposure criteria for ROPC *i* as calculated above ($\mu Ci/cm^3$)
44 = total number of individually quantified ROPCs (Ba-137m and Y-90 are included as daughter products and are not quantified separately)

The $AREC_M$ values for each of the ROPCs are provided in Supplement 4.

7.2.4.5 Toxicity of ROPCs to Nursing Infant

Nursing infant scenarios will be evaluated for exposure to ^{90}Sr, ^{129}I, ^{134}Cs, and ^{137}Cs. Background concentrations of ^{90}Sr, ^{129}I, ^{134}Cs, and ^{137}Cs in human breast milk are not available. The potential toxicity of these ROPCs to an infant will be evaluated using the ingestion *CSF* for each of the ROPCs to calculate lifetime cancer risk as described in Section 7.2.1.3.

7.3 Exposure Concentration, Lifetime Average Daily Dose, and Average Daily Dose

Inhalation dose is expressed as the exposure concentration (*EC*), while oral dose and dermal adsorption is expressed as intakes, or daily dose (as the sum of intakes). The exposure concentration is derived separately for carcinogens and noncarcinogens, but the term is used for both types of airborne constituents. For intake, carcinogens and noncarcinogens are further distinguished by terminology. For evaluating exposure to carcinogenic compounds, the intake is referred to as *LADD*. For evaluating exposure to noncarcinogenic compounds, the intake is referred to as *ADD*.

Cancer risk is estimated for each potentially carcinogenic COPC and ROPC as the product of the exposure concentration and unit risk factor, or the cumulative intake (*LADD*) and the slope factor. Non-cancer risk is estimated for each potentially noncarcinogenic COPC as the ratio of the exposure concentration and reference concentration, or the cumulative intake (*ADD*) and the reference dose. This

section describes the *EC*, the *LADD*, and the *ADD* as a prelude to risk characterization discussions where the quantitative assessment of risk due to exposure to carcinogens and noncarcinogens is described.

7.3.1 Exposure Concentration

For all inhalation pathways, the exposure concentration is used as a measure of receptor dose against which risk is evaluated. The equation in Table C-2-1 of the HHRAP serves as the basis for computing the exposure concentration due to long term (chronic) inhalation of emissions. Some receptor exposure scenarios include exposures that include time spent in what the RAGS Part F terms as "microenvironments", or exposures that last less than 24 hr/day. Per RAGS Part F Section 3.4.1, Equation 9 is applicable:

$$EC_j = \sum\left(C_a \cdot ET_j \cdot EF_j\right) \cdot \frac{ED_j}{AT_j \cdot CF} \qquad \text{(RAGS Part F Eq. 9)}$$

where:

C_a = concentration of COPC or ROPC in air (µg/m^3 or pCi/m^3) calculated as described in Section 6.1
EC_j = exposure concentration for microenvironment j (mg/m^3 or pCi/m^3)
ET_j = exposure time for microenvironment j (hr/day)
EF_j = exposure frequency microenvironment j (day/yr)
ED_j = exposure duration for microenvironment j (yr)
AT = averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) (yr)
CF = conversion factor (8760 hr/yr)

This is the same equation as presented in sections 7.1.5.1, 7.1.5.2 (substituting the concentration in airborne soil concentration for air concentration) and 7.1.5.5 (substituting airborne vapor and aerosol concentration for air concentration).

Per the RAGS Part F Section 3.4.2, to derive an average *EC* for a receptor over multiple exposure periods (e.g., exposures that occur for only a portion of the receptor's entire averaging time), the average *EC* from each period can be weighted by the fraction of the total exposure time that each period represents, using Equation 10 of the RAGS Part F.

$$EC_{LT} = \sum\left(EC_j \cdot ED_j\right) / AT \qquad \text{(RAGS Part F Eq. 10)}$$

where:

EC_{LT} = long-term average exposure concentration (mg/m^3 or pCi/m^3)
EC_j = exposure concentration for the period represented by ED_j (mg/m^3 or pCi/m^3)
ED_j = exposure duration for period j (yr)
AT = averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) (yr)

The equations below illustrate the computation of the *EC*. The equations below are based on HHRAP equations in Table C-2-1 with modifications to account for the differing receptor lifestyles. The equations which follow contain subscripted parameters (some absent in previous equations) to aid in distinguishing exposure pathways and constituent carcinogeneity.

Hanford site industrial worker:

for inhalation of COPCs and ROPCs via air:

$$EC_{inh\ job} = \frac{C_{a_{g\,max}} \cdot ET_{job} \cdot EF_{job} \cdot ED_{job}}{AT_{C\,worker}} \qquad EC_{inh\ job} = \frac{C_{a_{g\,max}} \cdot ET_{job} \cdot EF_{job} \cdot ED_{job}}{AT_{N\,worker}}$$

$$EC_{inh\ offs} = \frac{C_{a_{offs}} \cdot ET_{home} \cdot EF_{home} \cdot ED_{home}}{AT_{C\,worker}} \qquad EC_{inh\ offs} = \frac{C_{a_{offs}} \cdot ET_{home} \cdot EF_{home} \cdot ED_{home}}{AT_{N\,worker}}$$

$$EC_{inh\ wkend} = \frac{C_{a_{offs}} \cdot ET_{wkend} \cdot EF_{wkend} \cdot ED_{wkend}}{AT_{C\,worker}} \qquad EC_{inh\ wkend} = \frac{C_{a_{offs}} \cdot ET_{wkend} \cdot EF_{wkend} \cdot ED_{wkend}}{AT_{N\,worker}}$$

$$EC_{inh\ retire} = \frac{C_{a_{offs}} \cdot ET_{retire} \cdot EF_{retire} \cdot ED_{retire}}{AT_{C_{retire}}} \qquad EC_{inh\ retire} = \frac{C_{a_{offs}} \cdot ET_{retire} \cdot EF_{retire} \cdot ED_{retire}}{AT_{N_{retire}}}$$

$$EC_{inh} = EC_{inh\ job} \cdot \frac{ED_{job}}{AT_C} + EC_{inh\ offs} \cdot \frac{ED_{home}}{AT_C} + EC_{inh\ wkend} \cdot \frac{ED_{wkend}}{AT_C} + EC_{inh\ retire} \cdot \frac{ED_{retire}}{AT_C} \text{ or}$$

$$EC_{inh} = EC_{inh\ job} \cdot \frac{ED_{job}}{AT_N} + EC_{inh\ offs} \cdot \frac{ED_{home}}{AT_N} + EC_{inh_{wkend}} \cdot \frac{ED_{wkend}}{AT_N} + EC_{inh\ retire} \cdot \frac{ED_{retire}}{AT_N}$$

and inhalation of COPCs and ROPCs via resuspended soil:

$$EC_{soil\ job} = \frac{Cs_{g\,max}}{PEF} \cdot \frac{ET_{job} \cdot EF_{job} \cdot ED_{job}}{AT_{C\,worker}} \qquad EC_{soil\ job} = \frac{Cs_{tD_{g\,max}}}{PEF} \cdot \frac{ET_{job} \cdot EF_{job} \cdot ED_{job}}{AT_{N\,worker}}$$

$$EC_{soil\ offs} = \frac{Cs_{offs}}{PEF} \cdot \frac{ET_{home} \cdot EF_{home} \cdot ED_{home}}{AT_{C\,worker}} \qquad EC_{soil\ offs} = \frac{Cs_{tD_{offs}}}{PEF} \cdot \frac{ET_{home} \cdot EF_{home} \cdot ED_{home}}{AT_{N\,worker}}$$

$$EC_{soil\ wkend} = \frac{Cs_{off}}{PEF} \cdot \frac{ET_{wkend} \cdot EF_{wkend} \cdot ED_{wkend}}{AT_{C\,worker}} \qquad EC_{soil\ wkend} = \frac{Cs_{tD_{offs}}}{PEF} \cdot \frac{ET_{wkend} \cdot EF_{wkend} \cdot ED_{wkend}}{AT_{N\,worker}}$$

$$EC_{soil\ retire} = \frac{Cs_{offs}}{PEF} \cdot \frac{ET_{retire} \cdot EF_{retire} \cdot ED_{retire}}{AT_{C_{retire}}} \qquad EC_{soil\ retire} = \frac{Cs_{tD_{offs}}}{PEF} \cdot \frac{ET_{retire} \cdot EF_{retire} \cdot ED_{retire}}{AT_{N_{retire}}}$$

$$EC_{soil} = EC_{soil\ job} \cdot \frac{ED_{job}}{AT_C} + EC_{soil\ offs} \cdot \frac{ED_{home}}{AT_C} + EC_{soil\ wkend} \cdot \frac{ED_{wkend}}{AT_C} + EC_{soil\ retire} \cdot \frac{ED_{retire}}{AT_C}$$

$$EC_{soil} = EC_{soil\ job} \cdot \frac{ED_{job}}{AT_N} + EC_{soil\ offs} \cdot \frac{ED_{home}}{AT_N} + EC_{soil_{wkend}} \cdot \frac{ED_{wkend}}{AT_N} + EC_{soil\ retire} \cdot \frac{ED_{retire}}{AT_N}$$

where:

EC_{inh_j} = worker exposure concentration of COPCs or ROPCs through inhalation of emissions while at various microenvironments, *j*, defined by the subscripts below (Section 7.1.5.1) (mg/m^3 or pCi/m^3)

EC_{soil_j} = worker exposure concentration of COPCs or ROPCs through inhalation of resuspended soil while at various microenvironments, *j*, defined by the subscripts below (Section 7.1.5.2) (mg/m^3 or pCi/m^3)

EC_{inh} = long-term (cumulative) worker exposure concentration of COPCs or ROPCs through inhalation of emissions during the exposure scenario (note: the subscript "LT" is omitted for consistency with other receptors with non-periodic exposure scenarios) (mg/m^3 or pCi/m^3)

EC_{soil} = long-term worker exposure concentration of COPCs or ROPCs through inhalation of resuspended soil of emissions during the exposure scenario (note: the subscript "LT" is omitted for consistency with other receptors with non-periodic exposure scenarios) (mg/m^3 or pCi/m^3)

C_a = concentration of COPC or ROPC in air for each location of interest (ground maximum for on the job exposures, and offsite 90th percentile for after work, weekends, and during retirement) (Section 6.1) (μg/m^3 or pCi/m^3)

Cs_j = concentration of carcinogenic COPC or ROPC in soil for each location of interest (ground maximum for on the job exposures, and offsite 90th percentile for after work, weekends, and during retirement) (Section 6.2) (mg/kg or pCi/g)

Cs_{iD_j} = concentration of noncarcinogenic COPC in soil for each location of interest (ground maximum for on the job exposures, and offsite 90th percentile for after work, weekends, and during retirement) (Section 6.2) (mg/kg)

ET = exposure time (hr/day)

EF = exposure frequency (day/yr)

ED = exposure duration (yr)

AT = when shown with a receptor-specific subscript: averaging time for carcinogens ($AT_{C_{worker}}$ or $AT_{C_{retire}}$) or noncarcinogens ($AT_{N_{worker}}$ or $AT_{N_{retire}}$) corresponding to the worker or retiree exposure. When shown without a receptor-specific subscript: total scenario averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) corresponding to the worker plus retiree averaging time ($AT_{C_{worker}} + AT_{C_{retire}}$ or $AT_{N_{worker}} + AT_{N\,retire}$) (yr)

subscript *gmax* = value associated with the ground maximum location

subscript *offs* = value associated with the offsite location

subscript *job* = value associated with worker exposures on the job

subscript *home* = value associated with worker exposures after work, while presumably at home

subscript *wkend* = value associated with worker exposures on the weekends

subscript *retire* = value associated with exposures of the retired worker

Conversion factors are omitted for simplicity.

Resident, subsistence farmer, and subsistence fisher:

for inhalation of COPCs and ROPCs via air:

$$EC_{inh} = \frac{C_a \cdot ET \cdot EF \cdot ED}{AT_C} \qquad EC_{inh} = \frac{C_a \cdot ET \cdot EF \cdot ED}{AT_N}$$

and inhalation of COPCs and ROPCs via resuspended soil:

$$EC_{soil} = \frac{Cs}{PEF}\frac{ET \cdot EF \cdot ED}{AT_C} \qquad EC_{soil} = \frac{Cs_{tD}}{PEF}\frac{ET \cdot EF \cdot ED}{AT_N}$$

where:

- EC_{inh} = exposure concentration of COPCs or ROPCs through inhalation of emissions (Section 7.1.5.1) (mg/m^3 or pCi/m^3)
- EC_{soil} = exposure concentration of COPCs or ROPCs through inhalation of resuspended soil (Section 7.1.5.2) (mg/m^3 or pCi/m^3)
- C_a = offsite air concentration of COPC or ROPC in air (Section 6.1) (µg/m^3 or pCi/m^3)
- Cs = offsite soil concentration of carcinogenic COPC or ROPC (Section 6.2) (mg/kg or pCi/g)
- Cs_{tD} = offsite soil concentration of noncarcinogenic COPC (Section 6.2) (mg/kg)
- ET = exposure time (hr/day)
- EF = exposure frequency (day/yr)
- ED = exposure duration (yr)
- AT = averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) (yr)

Conversion factors are omitted for simplicity.

Resident Subsistence American Indian and Alternate Resident Subsistence American Indian #2:

for inhalation of COPCs and ROPCs via air:

$$EC_{inh} = \frac{C_a \cdot ET \cdot EF \cdot ED}{AT_C} \qquad EC_{inh} = \frac{C_a \cdot ET \cdot EF \cdot ED}{AT_N}$$

and inhalation of COPCs and ROPCs via resuspended soil:

$$EC_{soil} = \frac{Cs}{PEF}\frac{ET \cdot EF \cdot ED}{AT_C} \qquad EC_{soil} = \frac{Cs_{tD}}{PEF}\frac{ET \cdot EF \cdot ED}{AT_N}$$

and inhalation of COPCs and ROPCs via vapors and aerosols released during sweat lodge events:

Volatile and semivolatile organic COPC and volatile ROPC vapors:

$$EC_{sl} = C_{dw} \cdot \left(\frac{V_w}{2}\right) \cdot \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \frac{ET_{sl} \cdot EF_{sl} \cdot ED_{sl}}{AT_C} \qquad EC_{sl} = C_{dw} \cdot \left(\frac{V_w}{2}\right) \cdot \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \frac{ET_{sl} \cdot EF_{sl} \cdot ED_{sl}}{AT_N}$$

Non-volatile COPC and ROPC aerosols:

$$EC_{sl} = C_{dw} \cdot \left(\frac{MW_w}{R \cdot T_{sl} \cdot \rho_w}\right) \cdot e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)} \frac{ET_{sl} \cdot EF_{sl} \cdot ED_{sl}}{AT_C}$$

$$EC_{sl} = C_{dw} \cdot \left(\frac{MW_w}{R \cdot T_{sl} \cdot \rho_w}\right) \cdot e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)} \frac{ET_{sl} \cdot EF_{sl} \cdot ED_{sl}}{AT_N}$$

where:

- EC_{inh} = exposure concentration of COPCs or ROPCs through inhalation of emissions (Section 7.1.5.1) (mg/m^3 or pCi/m^3)
- EC_{soil} = exposure concentration of COPCs or ROPCs through inhalation of resuspended soil (Section 7.1.5.2) (mg/m^3 or pCi/m^3)
- EC_{sl} = exposure concentration of COPCs or ROPCs through inhalation in the sweat lodge (Section 7.1.5.5) (mg/m^3 or pCi/m^3)
- C_a = offsite air concentration of COPC or ROPC in air (Section 6.1) (µg/m^3 or pCi/m^3)
- Cs = offsite soil concentration of carcinogenic COPC or ROPC (Section 6.2) (mg/kg or pCi/g)
- Cs_{tD} = offsite soil concentration of noncarcinogenic COPC (Section 6.2) (mg/kg)
- C_{dw} = dissolved surface water concentration of COPCs and ROPCs (Section 6.3) (mg/L or pCi/L)
- V_W = volume of water (4 L)
- π = the constant *pi* (unitless); $\pi \approx 3.14159265359$
- r = radius of sweat lodge (1 m)
- MW_w = molar weight of water (18.01528 g/mol)
- R = ideal gas constant (0.06237 mmHg·m^3/gmole·K)
- T_{sl} = temperature of the sweat lodge (339 K)
- ρ_w = density of liquid water at temperature T_{sl} (980.2 g/L)
- ET_{sl} = sweat lodge exposure time (hr/day)
- EF_{sl} = sweat lodge exposure frequency (day/yr)
- ED_{sl} = sweat lodge exposure duration (yr)
- AT = averaging time for carcinogens (AT_C) or noncarcinogens (AT_N) (yr)
- e = base of the natural logarithm (unitless), ≈ 2.718282; the units for the Antoine equation, $e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)}$, are mmHg

Conversion factors are omitted for simplicity.

Alternate Resident Subsistence American Indian #1:

for inhalation of COPCs and ROPCs via air:

$$EC_{inh_{offs}} = \frac{C_{a_{offs}} \cdot ET_{home} \cdot EF_{home} \cdot ED_{home}}{AT_C} \qquad EC_{inh_{offs}} = \frac{C_{a_{offs}} \cdot ET_{home} \cdot EF_{home} \cdot ED_{home}}{AT_N}$$

$$EC_{inh_{gbl}} = \frac{C_{a_{gbl}} \cdot ET_{gbl} \cdot EF_{gbl} \cdot ED_{gbl}}{AT_C} \qquad EC_{inh_{gbl}} = \frac{C_{a_{offs}} \cdot ET_{gbl} \cdot EF_{gbl} \cdot ED_{gbl}}{AT_{N\,gbl}}$$

$$EC_{inh} = EC_{inh_{offs}} \cdot \frac{ED_{home}}{AT_C} + EC_{inh_{gbl}} \cdot \frac{ED_{gbl}}{AT_C} \qquad EC_{inh} = EC_{inh_{offs}} \cdot \frac{ED_{home}}{AT_N} + EC_{inh_{gbl}} \cdot \frac{ED_{gbl}}{AT_N}$$

and inhalation of COPCs and ROPCs via resuspended soil:

$$EC_{soil_{offs}} = \frac{Cs_{offs}}{PEF} \cdot \frac{ET_{home} \cdot EF_{home} \cdot ED_{home}}{AT_C} \qquad EC_{soil_{offs}} = \frac{Cs_{tD_{offs}}}{PEF} \cdot \frac{ET_{home} \cdot EF_{home} \cdot ED_{home}}{AT_N}$$

$$EC_{soil_{gbl}} = \frac{Cs_{gbl}}{PEF} \cdot \frac{ET_{gbl} \cdot EF_{gbl} \cdot ED_{gbl}}{AT_C} \qquad EC_{soil_{gbl}} = \frac{Cs_{tD_{gbls}}}{PEF} \cdot \frac{ET_{gbl} \cdot EF_{gbl} \cdot ED_{gbl}}{AT_N}$$

$$EC_{soil} = EC_{soil_{offs}} \cdot \frac{ED_{home}}{AT_C} + EC_{soil_{gbl}} \cdot \frac{ED_{gbl}}{AT_C} \qquad EC_{soil} = EC_{soil_{offs}} \cdot \frac{ED_{home}}{AT_N} + EC_{soil_{gbl}} \cdot \frac{ED_{gbl}}{AT_N}$$

and inhalation of COPCs and ROPCs via vapors and aerosols released during sweat lodge events:

Volatile and semivolatile organic COPC and volatile ROPC vapors:

$$EC_{sl} = C_{dw} \cdot \left(\frac{V_w}{2}\right) \cdot \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \frac{ET_{sl} \cdot EF_{sl} \cdot ED_{sl}}{AT_C} \qquad EC_{sl} = C_{dw} \cdot \left(\frac{V_w}{2}\right) \cdot \left(\frac{1}{\frac{2}{3} \cdot \pi \cdot r^3}\right) \frac{ET_{sl} \cdot EF_{sl} \cdot ED_{sl}}{AT_N}$$

Non-volatile COPC and ROPC aerosols:

$$EC_{sw} = C_{dw} \cdot \left(\frac{MW_w}{R \cdot T_{sl} \cdot \rho_w}\right) \cdot e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)} \frac{ET_{sl} \cdot EF_{sl} \cdot ED_{sl}}{AT_C}$$

$$EC_{sw} = C_{dw} \cdot \left(\frac{MW_w}{R \cdot T_{sl} \cdot \rho_w}\right) \cdot e^{\left(18.3036 - \frac{3816.44}{T_{sl} - 46.13}\right)} \frac{ET_{sl} \cdot EF_{sl} \cdot ED_{sl}}{AT_N}$$

where:

EC_{inh} = exposure concentration of COPCs or ROPCs through inhalation of emissions (Section 7.1.5.1) (mg/m^3 or pCi/m^3)

EC_{soil} = exposure concentration of COPCs or ROPCs through inhalation of resuspended soil (Section 7.1.5.2) (mg/m^3 or pCi/m^3)

EC_{sl} = exposure concentration of COPCs or ROPCs through inhalation in the sweat lodge (Section 7.1.5.5) (mg/m^3 or pCi/m^3)

subscript *offs* = value associated with the offsite location

subscript *home* = value associated with time spent at home (offsite location)

subscript *gbl* = value associated with ceremonial activities, presumably at the Gable Mountain location

Other variables are defined above. Conversion factors are omitted for simplicity.

7.3.2 Lifetime Average and Average Daily Dose

For evaluating exposure to carcinogenic compounds, the intake is referred to as *LADD*. For evaluating exposure to noncarcinogenic compounds, the intake is referred to as *ADD*. The *LADD* is equivalent to the dose to the receptor averaged over a lifetime, while the *ADD* is the average dose to the receptor over the exposure period. The *LADD* is a chronic dose used for assessing long term cancer risk while the *ADD* is the average threshold dose used for assessing the hazard. For COPCs, the daily intake, *I*, must be converted to a dose (*LADD* and *ADD*) by applying receptor specific parameters such as exposure frequency and duration, body weight, etc. For ROPCs, the equations for daily intake, *I*, generally equates to the LADD because such receptor-specific parameters are already included in the ROPC equations (see Section 7.1.5). The equations which follow contain subscripted parameters (some absent in previous equations) to aid in distinguishing exposure pathways and constituent carcinogeneity.

The *LADD* and *ADD* (due to oral intake) is calculated as the product of the daily intake and the lifetime exposure frequency (*EF*) and duration (*ED*) divided by the risk averaging time (*AT*) of the exposure pathway. Values for *EF* and *ED* are pathway specific (that is, specific to the time of exposure to soil, or time during which a specific diet is consumed or water is consumed). The application of *EF* and *ED* to the *LADD* and *ADD* computation is important because it distinguishes the lifetime dose for the various receptor/exposure pathway combinations used in the risk assessment. The value of the risk averaging time for a carcinogen (AT_C) is the lifetime of the receptor (generally, this is 70 years). The value of the risk averaging time for a noncarcinogen (AT_N) is the exposure duration (*ED*) of the receptor.

The equations below illustrate the computation of the *LADD* and *ADD*. Note that the equations below are based on HHRAP equations in tables C-1-7 and C-1-8 with modifications to account for the differing receptor lifestyles. Equations for ROPCs already include terms for an average lifetime exposure so the intake, *I*, for an ROPC is the same as the *LADD* for a ROPC. Computing the *LADD* and *ADD* based upon daily intake yields:

Hanford site industrial worker and resident:

for COPCs:

$$LADD_{o_{soil}} = I_{soil} \cdot \frac{EF_{soil} \cdot ED_{soil}}{AT_C} \qquad ADD_{o_{soil}} = I_{soil} \cdot \frac{EF_{soil} \cdot ED_{soil}}{AT_N}$$

$$LADD_{o_{food}} = I_{ag} \cdot \frac{EF_{food} \cdot ED_{food}}{AT_C} \qquad ADD_{o_{food}} = I_{ag} \cdot \frac{EF_{food} \cdot ED_{food}}{AT_N}$$

$$LADD_{o_{dw}} = I_{dw} \cdot \frac{EF_{dw} \cdot ED_{dw}}{AT_C} \qquad ADD_{o_{dw}} = I_{dw} \cdot \frac{EF_{dw} \cdot ED_{dw}}{AT_N}$$

for ROPCs:

$$LADD_{o_{soil}} = I_{soil}$$

$$LADD_{o_{food}} = I_{ag}$$

$$LADD_{o_{dw}} = I_{dw}$$

Resident subsistence farmer:

for COPCs:

$$LADD_{o_{soil}} = I_{soil} \cdot \frac{EF_{soil} \cdot ED_{soil}}{AT_C} \qquad ADD_{o_{soil}} = I_{soil} \cdot \frac{EF_{soil} \cdot ED_{soil}}{AT_N}$$

$$LADD_{o_{food}} = \begin{pmatrix} I_{ag} + I_{beef} + I_{milk} + \\ I_{pork} + I_{chicken} + I_{egg} \end{pmatrix} \cdot \frac{EF_{food} \cdot ED_{food}}{AT_C} \qquad ADD_{o_{food}} = \begin{pmatrix} I_{ag} + I_{beef} + I_{milk} + \\ I_{pork} + I_{chicken} + I_{egg} \end{pmatrix} \cdot \frac{EF_{food} \cdot ED_{food}}{AT_N}$$

$$LADD_{o_{dw}} = I_{dw} \cdot \frac{EF_{dw} \cdot ED_{dw}}{AT_C} \qquad ADD_{o_{dw}} = I_{dw} \cdot \frac{EF_{dw} \cdot ED_{dw}}{AT_N}$$

for ROPCs:

$$LADD_{o_{soil}} = I_{soil}$$

$$LADD_{o_{food}} = I_{ag} + I_{beef} + I_{milk} + I_{pork} + I_{chicken} + I_{egg}$$

$$LADD_{o_{dw}} = I_{dw}$$

Resident subsistence fisher:

for COPCs:

$$LADD_{o_{soil}} = I_{soil} \cdot \frac{EF_{soil} \cdot ED_{soil}}{AT_C} \qquad ADD_{o_{soil}} = I_{soil} \cdot \frac{EF_{soil} \cdot ED_{soil}}{AT_N}$$

$$LADD_{o_{food}} = (I_{ag} + I_{fish}) \cdot \frac{EF_{food} \cdot ED_{food}}{AT_C} \qquad ADD_{o_{food}} = (I_{ag} + I_{fish}) \cdot \frac{EF_{food} \cdot ED_{food}}{AT_N}$$

$$LADD_{o_{dw}} = I_{dw} \cdot \frac{EF_{dw} \cdot ED_{dw}}{AT_C} \qquad ADD_{o_{dw}} = I_{dw} \cdot \frac{EF_{dw} \cdot ED_{dw}}{AT_N}$$

for ROPCs:

$$LADD_{o_{soil}} = I_{soil}$$

$$LADD_{o_{food}} = I_{ag} + I_{fish}$$

$$LADD_{o_{dw}} = I_{dw}$$

Resident Subsistence American Indian:

for COPCs:

$$LADD_{o_{soil}} = I_{soil} \cdot \frac{EF_{soil} \cdot ED_{soil}}{AT_C} \qquad ADD_{o_{soil}} = I_{soil} \cdot \frac{EF_{soil} \cdot ED_{soil}}{AT_N}$$

$$LADD_{o_{food}} = \begin{pmatrix} I_{ag} + I_{game} + I_{wild\ fowl} + \\ I_{wild\ eggs} + I_{fish} \end{pmatrix} \cdot \frac{EF_{food} \cdot ED_{food}}{AT_C} \qquad ADD_{o_{food}} = \begin{pmatrix} I_{ag} + I_{game} + I_{wild\ fowl} + \\ I_{wild\ eggs} + I_{fish} \end{pmatrix} \cdot \frac{EF_{food} \cdot ED_{food}}{AT_N}$$

$$LADD_{o_{dw}} = I_{dw} \cdot \frac{EF_{dw} \cdot ED_{dw}}{AT_C} \qquad ADD_{o_{dw}} = I_{dw} \cdot \frac{EF_{dw} \cdot ED_{dw}}{AT_N}$$

for ROPCs:

$$LADD_{o_{soil}} = I_{soil}$$

$$LADD_{o_{food}} = I_{ag} + I_{wild\ fowl} + I_{wild\ egg} + I_{game} + I_{fish}$$

$$LADD_{o_{dw}} = I_{dw}$$

where:

$LADD_{o_{soil}}$	=	lifetime average daily dose from soil ingestion (unitless)
$LADD_{o_{food}}$	=	lifetime average daily dose from food ingestion (unitless)
$LADD_{o_{dw}}$	=	lifetime average daily dose from water ingestion (unitless)
$ADD_{o_{soil}}$	=	average daily dose from soil ingestion (unitless)
$ADD_{o_{food}}$	=	average daily dose from food ingestion (unitless)
$ADD_{o_{dw}}$	=	average daily dose from water ingestion (unitless)
I_{soil}	=	intake of COPC or ROPC due to soil ingestion (Section 7.1.5.2) (mg/kg·day or pCi)
I_{ag}	=	intake of COPC or ROPC through ingestion of produce (Section 7.1.5.3) (mg/kg·day or pCi)
I_{beef}	=	intake of COPC or ROPC through ingestion of beef (Section 7.1.5.3) (mg/kg·day or pCi)

I_{milk}	=	intake of COPC or ROPC through ingestion of milk (Section 7.1.5.3) (mg/kg·day or pCi)
I_{pork}	=	intake of COPC or ROPC through ingestion of pork (Section 7.1.5.3) (mg/kg·day or pCi)
$I_{chicken}$	=	intake of COPC or ROPC through ingestion of chicken (Section 7.1.5.3) (mg/kg·day or pCi)
I_{egg}	=	intake of COPC or ROPC through ingestion of eggs (Section 7.1.5.3) (mg/kg·day or pCi)
I_{game}	=	intake of COPC or ROPC through ingestion of game (Section 7.1.5.3) (mg/kg·day or pCi)
$I_{wild\ fowl}$	=	intake of COPC or ROPC through ingestion of wild fowl (Section 7.1.5.3) (mg/kg·day or pCi)
$I_{wild\ egg}$	=	intake of COPC or ROPC through ingestion of wild eggs (Section 7.1.5.3) (mg/kg·day or pCi)
I_{dw}	=	intake of COPC or ROPC from drinking water (Section 7.1.5.4) (mg/kg·day or pCi)
EF_{soil}	=	soil exposure frequency (day/yr), the number of days per year the receptor is at a location exposed to incidental soil ingestion.
ED_{soil}	=	soil exposure duration (yr), the number of years the receptor is at a location exposed to incidental soil ingestion.
EF_{food}	=	food exposure frequency (day/yr), the number of days per year a receptor consumes a food type used to assess the exposure through food ingestion (e.g., produce, game, beef, fish, etc.).
ED_{food}	=	food exposure duration (yr), the number of years a receptor consumes a food type used to assess the exposure through food ingestion (e.g. produce, game, beef, fish, etc.).
EF_{dw}	=	drinking water exposure frequency (day/yr), the number of days per year the receptor drinks water from the Columbia River.
ED_{dw}	=	drinking water exposure duration (yr), the number of years the receptor drinks water from the Columbia River.
BW	=	body weight (kg)
AT_C	=	averaging time for carcinogens (yr), generally equal to the receptor's lifespan (70 years)
AT_N	=	averaging time for noncarcinogens (yr), generally equal to the receptor's exposure duration (ED)

Conversion factors are omitted for simplicity.

7.3.3 External and Dermal Dose

The external dose is consider the dose adsorbed by the receptor due to external radiation (from air and soil) exposure while dermal dose is the dose absorbed through the skin by immersion to constituents. Dermal dose is only assessed in a sweat lodge exposure scenario.

For airborne ROPCs, the *LADD* is computed as:

$$LADD_{ira} = I_{ira}$$

where:

$LADD_{ira}$ = lifetime average daily dose, or intake, I_{ira}, from external radiation for airborne ROPCs ($Bq \cdot sec/m^3$)

I_{ira} = external exposure to gamma radiation from ROPCs in air (Section 7.1.5.1) ($Bq \cdot sec/m^3$)

For ROPCs in surface soil, the *LADD* is computed as:

$$LADD_{irs} = I_{irs}$$

where:

$LADD_{irs}$ = lifetime average daily dose, or intake, I_{irs}, from external radiation for ROPCs in soil ($pCi \cdot yr/g$)

I_{irs} = external exposure to gamma radiation from ROPCs in soil (Section 7.1.5.2) ($pCi \cdot yr/g$)

For the resident subsistence American Indian exposure scenario(s), dermal absorption occurs in the sweat lodge. The equations for computing the *LADD* and *ADD* from the dermal sweat lodge pathway are:

COPCs: $$LADD_d = I_d \cdot \frac{EF_{sl} \cdot ED_{sl}}{AT_C} \text{ and}$$

$$ADD_d = I_d \cdot \frac{EF_{sl} \cdot ED_{sl}}{AT_N}$$

where:

$LADD_d$ = lifetime average daily dose, or intake, I_d, from dermal absorption of condensate and vapors within the sweat lodge (mg/kg·day)

I_d = intake of COPCs from adult dermal absorption within the sweat lodge (Section 7.1.5.5) (mg/kg·day or pCi)

EF_{sl} = sweat lodge exposure frequency (day/yr)

ED_{sl} = sweat lodge exposure duration (yr)

AT_C = averaging time for carcinogens (yr), generally equal to the receptor's lifespan (70 years)

AT_N = averaging time for noncarcinogens (yr), generally equal to the receptor's exposure duration (*ED*)

7.4 Risk Characterization

The purpose of the risk characterization is to evaluate the information obtained through the exposure (Section 7.1), toxicity (Section 7.2), and dose (Section 7.3) assessments to estimate the potential for receptors to experience adverse effects (cancer risks and noncancer hazards) as a result of exposure to media contaminated by emissions from the WTP. Potential health risks will be characterized separately for noncarcinogenic and carcinogenic endpoints, and chemical (i.e., nonradiological) and radiological cancer risks will be evaluated and presented separately.

7.4.1 Risk Characterization for Carcinogens

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to a carcinogen. Cancer risk from exposure to contamination is expressed as *ILCR*, or the increased chance of cancer above the normal background rate of cancer. Cancer risk from external exposure to ionizing radiation is expressed in terms of morbidity.

The threshold for the total *ILCR* for COPCs, the total *ILCR* for ROPCs, and the constituent-specific and pathway-specific *ILCR* for COPCs and ROPCs is 1E-05, or 1 in 100,000 exposed individuals (EPA 2005a). The total *ILCR* is the sum of all the constituent-specific *ILCR*s for COPCs and ROPCs of applicable pathways (inhalation, oral, and external) for each receptor.

7.4.1.1 Inhalation Risk for Carcinogens

Cancer risk is estimated for each potentially carcinogenic COPC as the product of the unit risk factor and the exposure concentration (EPA 2005a and EPA 2001):

For all inhalation pathways:

$$ILCR_{inh} = \sum EC_i \times URF \qquad \text{(HHRAP Eq. 7-1)}$$

where:

$ILCR_{inh}$ = incremental lifetime cancer risk from inhalation pathways (unitless)

EC_i = exposure concentration of COPCs through inhalation from pathway i (mg/m^3). For all receptors except those in American Indian scenarios, the EC_i is due to air and resuspended soil exposure (Sections 7.1.5.1 and 7.1.5.2). For tribal scenarios, EC_i includes exposure to air, soil, and exposure in the sweat lodge (Section 7.1.5.5).

URF = unit risk factor ($m^3/\mu g$)

However, for ROPCs, the cancer risk is estimated as the product of the slope factor and the intake. Recall that:

$$I_i = EC_i \cdot IR \cdot AT \cdot CF \qquad \text{(modified HHRAP Table C-3-1)}$$

where:

I_i = intake of ROPC via inhalation pathway i (pCi)

EC_i = exposure concentration of ROPCs through inhalation from pathway i (pCi/m^3). For all receptors except those in American Indian scenarios, the EC_i is due to air and resuspended soil exposure (Sections 7.1.5.1 and 7.1.5.2). For American Indian scenarios, EC_i includes exposure to air, soil, and exposure in the sweat lodge (Section 7.1.5.5).

IR = inhalation rate (m^3/hr)

AT = averaging time for carcinogens (AT_C) (yr)

CF = units conversion factor of 8760 (hr/yr)

So that for ROPC exposure via inhalation pathways, the equation for risk is the product of intake and the slope factor:

$$ILCR_{inh} = \sum (I_i \times CSF_{inh}) \qquad \text{(modified HHRAP Eq. 7-2)}$$

This yields the following receptor-specific equations:

Hanford site industrial worker, resident, farmer, and fisher:

COPCs: $ILCR_{inh} = (EC_{inh} + EC_{soil}) \cdot URF$

ROPCs: $ILCR_{inh} = (EC_{inh} + EC_{soil}) \cdot IR \cdot AT \cdot CSF_{inh} \cdot CF$ or $ILCR_{inh} = (I_{inh} + I_{inhsoil}) \cdot CSF_{inh}$

Resident Subsistence American Indian(s):

COPCs: $ILCR_{inh} = (EC_{inh} + EC_{soil} + EC_{sl}) \cdot URF$

ROPCs: $ILCR_{inh} = (EC_{inh} + EC_{soil} + EC_{sl}) \cdot IR \cdot AT \cdot CSF_{inh} \cdot CF$ or
$ILCR_{inh} = (I_{inh} + I_{inhsoil} + I_{sl}) \cdot CSF_{inh}$

where:

$ILCR_{inh}$ = incremental lifetime cancer risk from inhalation pathways (unitless)

EC_{inh} = exposure concentration of COPCs or ROPCs through inhalation of emissions (Section 7.1.5.1) (mg/m^3 or pCi/m^3)

EC_{soil} = exposure concentration of COPCs or ROPCs through inhalation of resuspended soil (Section 7.1.5.2) (mg/m^3 or pCi/m^3)

EC_{sl} = exposure concentration of COPCs or ROPCs through inhalation in the sweat lodge (Section 7.1.5.5) (mg/m^3 or pCi/m^3)

I_{inh} = intake of ROPCs through inhalation of emissions (Section 7.1.5.1) (pCi)

I_{soil} = intake of ROPCs through inhalation of resuspended soil (Section 7.1.5.2) (pCi)

I_{sl} = intake of ROPCs through inhalation in the sweat lodge (Section 7.1.5.5) (pCi)

URF = unit risk factor (m^3/µg)

CSF_{inh} = radionuclide-specific inhalation cancer slope factor (pCi^{-1})

CF = units conversion factor of 8760 (hr/yr)

7.4.1.2 Oral Risk for Carcinogens

For all oral (ingestion) pathways of constituents, Equation 7-2 of the HHRAP is used, with modifications for the pathway-specific *CSF*s that apply (refer to EPA 2001):

$$ILCR_o = \sum\left(LADD_{o_i} \times CSF_{o_i}\right) \qquad \text{(modified HHRAP Eq. 7-2)}$$

Such that:

for COPCs: $ILCR_o = \left(LADD_{o_{soil}} + LADD_{o\,food} + LADD_{o_{dw}}\right) \cdot CSF_{oral}$

for ROPCs: $ILCR_o = LADD_{o_{soil}} \cdot CSF_{soil} + LADD_{o\,food} \cdot CSF_{food} + LADD_{o_{dw}} \cdot CSF_{dw}$

where:

$ILCR_o$	=	incremental lifetime cancer risk from oral pathways (ingestion) (unitless)
$LADD_{o_i}$	=	lifetime average daily dose, or intake, of constituent via ingestion pathway *i* (water ingestion, food ingestion, and soil ingestion, as applicable) (pCi).
CSF_{o_i}	=	pathway-specific ingestion *CSF* for pathway *i* (for COPCs, this is the oral *CSF*, for ROPCs, this is the water ingestion, food ingestion, and soil ingestion *CSF* as applicable) (pCi^{-1}).
$LADD_{o_{soil}}$	=	incremental lifetime cancer risk from soil ingestion (unitless)
$LADD_{o\,food}$	=	incremental lifetime cancer risk from food ingestion (unitless)
$LADD_{o_{dw}}$	=	incremental lifetime cancer risk from water ingestion (unitless)
CSF_{oral}	=	chemical-specific oral (ingestion) *CSF* (kg·day/mg)
CSF_{soil}	=	radionuclide-specific soil ingestion *CSF* (pCi^{-1})
CSF_{food}	=	radionuclide-specific food ingestion *CSF* (pCi^{-1})
CSF_{dw}	=	radionuclide-specific water ingestion *CSF* (pCi^{-1})

7.4.1.3 External and Absorption Risk for Carcinogens

For COPC and ROPC exposure from external pathways (skin adsorption in the sweat lodge, and external ROPC exposures from air and soil), the cancer risk is estimated for each potentially carcinogenic COPC and ROPC as the product of the slope factor and the cumulative intake or external exposure (EPA 2005a and EPA 1999c):

$$ILCR_e = \sum\left(LADD_i \times CSF_i \text{ or } RF_{air}\right) \qquad \text{HHRAP, Eq. 7-2}$$

or, more specifically:

COPCs: $ILCR_e = ILCR_{e_{dermal}}$

ROPCs: $ILCR_e = ILCR_{e_{soil}} + ILCR_{e_{air}}$

where:

$ILCR_e$ = incremental lifetime cancer risk from external pathways (ingestion) (unitless)
$LADD_i$ = lifetime average daily dose, or intake, I, of constituent via pathway i (dermal absorption, external air and soil exposure) (mg/kg·day, pCi·yr/g, or Bq·sec/m^3)
CSF_i = constituent-specific external pathway CSF for pathway i (dermal absorption, soil exposure) (kg·day/mg or pCi^{-1})
RF_{air} = radionuclide-specific risk coefficient for morbidity for pathway i (external air) (m^3/Bq·sec)

Other variables are defined below.

For exposure to ionizing radiation in soil, the following equation is used (EPA 1999c):

$$ILCR_{e_{soil}} = LADD_{irs} \times CSF_{adj}$$

where:

$ILCR_{e_{soil}}$ = incremental lifetime cancer risk due to external exposure to radionuclides in soil (unitless)
$LADD_{irs}$ = lifetime average daily dose to radiation from ROPCs in soil, I_{irs}, from ROPCs in soil (pCi·yr/g).
CSF_{adj} = adjusted cancer slope factor for 5 cm depth (Section 7.2.4.2) (pCi^{-1})

For exposure to ionizing radiation in air, the following equation is used (EPA 1999c):

$$ILCR_{e_{air}} = LADD_{ira} \times RF_{air}$$

where:

$ILCR_{e_{air}}$ = incremental lifetime cancer risk due to external exposure to radionuclides in air (unitless)
$LADD_{ira}$ = lifetime average daily dose, or intake, I_{ira}, from radiation from ROPCs in air (Bq·sec/m^3).
RF_{air} = radionuclide-specific risk coefficient for morbidity for external air (Section 7.2.4.3) (m^3/Bq·sec)

For COPC exposure from dermal absorption pathways (skin adsorption in the sweat lodge), the HHRAP Equation 7-2 is used in conjunction with CSF_{dermal} as presented in Section 7.2.1.1 for COPCs:

$$ILCR_{e_{dermal}} = LADD_d \times CSF_{dermal} \qquad \text{(modified HHRAP Eq. 7-2)}$$

where:

$ILCR_{e_{dermal}}$ = incremental lifetime cancer risk due to dermal absorption pathways (unitless). This quantity is only calculated for sweat lodge exposures

$LADD_d$ = lifetime average daily dose, or intake, I_d, from dermal absorption of condensate and vapors within the sweat lodge (mg/kg·day)

CSF_{dermal} = dermal cancer slope factor (kg·day/mg)

The equations above yield the following receptor-specific equations:

Hanford site industrial worker[9], resident, farmer, and fisher:

COPCs: not determined

ROPCs: $ILCR_e = LADD_{irs} \cdot CSF_{adj} + LADD_{ira} \cdot RF_{air}$

Resident Subsistence American Indian(s):

COPCs: $ILCR_e = LADD_d \cdot CSF_{dermal}$

ROPCs: $ILCR_e = LADD_{irs} \cdot CSF_{adj} + LADD_{ira} \cdot RF_{air}$

7.4.1.4 Additivity of Dioxins and PCBs

Chlorinated dioxins, chlorinated dibenzofurans, and coplanar chlorinated biphenyls are similar structurally and may act through common mechanisms of toxicity. Because they may have a common mechanism of action, it is assumed that the toxicity of these chemicals is additive (WHO 1998, EPA 2005a). This additivity is addressed in the risk characterization by presenting a total risk from PCDDs, PCDFs, and coplanar PCBs in addition to presenting individual risks from these chemicals.

7.4.1.5 Additivity of Other Potential Carcinogens

The assumption of strict additivity of chemical carcinogens assumes that (1) intakes of individual chemicals are small, and (2) there is no interaction among chemicals (i.e., no synergism or antagonism). Uncertainties associated with the assumption of additivity of chemical carcinogens will be discussed in the uncertainty section of the PRA. Despite the uncertainty, a total ILCR from exposure to all carcinogenic COPCs will be calculated as the sum of the chemical-specific ILCRs.
The assumption of strict additivity of cancer risk from radionuclides is much less uncertain. A total ILCR from exposure to all ROPCs will be calculated as the sum of the radionuclide-specific ILCRs.

[9] Includes exposure during adulthood through retirement.

7.4.2 Risk Characterization for Noncarcinogens

Noncarcinogenic health hazards are characterized using a hazard quotient (*HQ*) and hazard index (*HI*) approach. The *HQ* is the ratio of the calculated *ADD* to the reference or "safe" dose as shown below:

$$HQ = \frac{ADD}{RfD} \text{ or } HQ = \frac{EC}{RfC} \qquad \text{(HHRAP Eq. 7-5)}$$

where:

HQ = hazard quotient (unitless)
ADD = average daily dose (mg/kg·day)
RfD = reference dose (mg/kg·day)
EC = exposure air concentration (mg/m^3)
RfC = reference concentration (mg/m^3)

The *HQ*s will be calculated for each noncarcinogenic COPC. The ROPCs having potential health effects unassociated with radioactivity (i.e., noncancer effects) will be evaluated as inorganic COPCs. An *HQ* of 1 or less indicates that the chemical-specific *ADD* is below the level associated with adverse effect. An *HQ* threshold level of 0.25 has been selected as a risk management decision by Ecology and EPA Region 10 to provide a conservative evaluation of hazard and is consistent with other EPA guidance (EPA 1998).

7.4.2.1 Inhalation Risk for Noncarcinogens

The hazard index is estimated for each noncarcinogenic COPC as the quotient of the exposure concentration and reference concentration:

For all inhalation pathways:

$$HQ_{inh} = \frac{\sum EC_i}{RfC} \qquad \text{(HHRAP Eq. 7-5)}$$

where:

HQ_{inh} = hazard quotient from inhalation pathways (unitless)
EC_i = exposure concentration of COPCs through inhalation of emissions from pathway *i* (mg/m^3). For all receptors except those in American Indian scenarios, the inhalation pathways include air and resuspended soil exposure (Sections 7.1.5.1 and 7.1.5.2). For American Indian scenarios, inhalation pathways include exposure to air, soil, and exposure in the sweat lodge (Section 7.1.5.5).
RfC = chemical-specific inhalation reference concentration (mg/m^3)

This yields the following receptor-specific equations:

Hanford site industrial worker, resident, farmer, and fisher:

$$HQ_{inh} = \left(EC_{inh} + EC_{soil}\right) \div RfC$$

Resident Subsistence American Indian(s):

$$HQ_{inh} = \left(EC_{inh} + EC_{soil} + EC_{sl}\right) \div RfC$$

7.4.2.2 Oral Risk for Noncarcinogens

For all oral (ingestion) pathways of constituents, Equation 7-5 of the HHRAP is used:

$$HQ_o = \sum ADD_{o_i} \div RfD_{oral}$$

Such that:

$$HQ_o = \left(ADD_{o_{soil}} + ADD_{o_{food}} + ADD_{o_{dw}}\right) \div RfD_{oral}$$

where:

HQ_o = hazard quotient from oral pathways (ingestion) (unitless)

ADD_{o_i} = average daily dose, or intake, of constituent via ingestion pathway *i* (water ingestion, food ingestion, and soil ingestion, as applicable) (mg/kg·day).

RfD_{oral} = ingestion *RfD* (mg/kg·day).

$ADD_{o_{soil}}$ = incremental lifetime cancer risk from soil ingestion (unitless)

$ADD_{o_{food}}$ = incremental lifetime cancer risk from food ingestion (unitless)

$ADD_{o_{dw}}$ = incremental lifetime cancer risk from water ingestion (unitless)

7.4.2.3 Absorption Risk for Noncarcinogens

There is no external radiation exposure pathway associated with COPCs. For COPC exposure from dermal absorption pathways (skin adsorption in the sweat lodge), the HHRAP Equation 7-5 is used in conjunction with RfD_{dermal} as presented in Section 7.2.1.1 for COPCs:

$$HQ_d = ADD_d \div RfD_{dermal} \qquad \text{(HHRAP Eq. 7-5)}$$

where:

HQ_d = incremental lifetime cancer risk due to dermal absorption pathways (unitless). This quantity is only calculated for sweat lodge exposures

ADD_d = average daily dose, or intake, I_d, from dermal absorption of condensate and vapors within the sweat lodge (mg/kg·day)

RfD_{dermal} = dermal reference dose (mg/kg·day)

7.4.2.4 Additivity of Noncarcinogens

Multiple chemical exposures can result in synergism, antagonism, and/or additivity of biological responses when the chemicals act on similar target organs or when they are metabolized by the same enzymatic pathways. Additivity of noncarcinogenic health effects should only be considered if the chemicals have the same toxicological endpoint (e.g., organ or enzyme system), which implies the same mechanism of action. Additivity for all chemicals will initially be assumed for the SLRA regardless of toxicological mechanism or endpoint. This approach is likely to overestimate the true human health risks associated with exposure to the COPCs, since many chemicals may act on different target organs. If the target hazard index (*HI*) is exceeded, a segregation of the *HI* by toxicological endpoint will be considered. If segregation by toxicological endpoint is used, chemical groupings by endpoint will be assigned with approval by Ecology and EPA. In addition to multiple chemicals, receptors will be assumed to be exposed to the multiple pathways identified in Table 7-1.

The simplified equation for calculating a generic *HI* is presented below:

$$HI = \sum HQ_i \qquad \text{(HHRAP Eq. 7-6)}$$

where:

HI = hazard index for a specific exposure pathway
HQ_i = hazard quotient for COPC *i*

An *HI* threshold level of 0.25 will be used in the SLRA to provide a conservative evaluation of hazard.

7.4.3 Risk Characterization for Acute Effects

Acute health hazards are characterized using an acute hazard quotient (*AHQ*). The *AHQ* is the ratio of the one-hour acute air concentration to the appropriate acute reference value as shown below:

COPCs: $AHQ = C_{acute} \div AIEC$ (HHRAP Eq. 7-9)

ROPCs: $AHQ = C_{acute} \div AREC_M$ (modified HHRAP Eq. 7-9)

where:

C_{acute} = one-hour acute air concentration (mg/m^3 or $\mu Ci/m^3$)
AHQ = acute hazard quotient (unitless)
$AIEC$ = acute inhalation exposure criteria (Section 7.2.1.2) (mg/m^3)
$AREC_M$ = acute radionuclide exposure criteria (Section 7.2.4.4) ($\mu Ci/cm^3$)

As defined by the above equation, an *AHQ* of 1 or less indicates that the maximum one-hour air concentration is below the reference value. An *AHQ* threshold level of 1 is used to provide a conservative evaluation of hazard per EPA (CCN 063809).

7.5 Uncertainty in Human Health Risk Assessment

This section provides an overview of some of the primary sources of uncertainty unique to the HHRA. Uncertainties associated with the COPC and ROPC selection, emission rates, and environmental modeling, described in previous sections, also contribute to the uncertainty in the HHRA. As described in Section 10 of this RAWP, an uncertainty assessment will be included in the SLRA to evaluate the contributors to, and potential impact of, uncertainty in the risk assessment.

7.5.1 Uncertainty in Exposure Assessment

Sources of uncertainty in the exposure assessment include:

- Contaminant concentrations in exposure media
- Land-use assumptions
- Selection of representative human receptor populations and exposure parameter values
- The makeup of the waste stream, the formation of PICs, and the modeling of emissions

Each of these sources of uncertainty in the exposure assessment is described briefly below.

Contaminant Concentrations in Exposure Media

The uncertainty associated with estimating exposure concentrations in air, soil, surface water, sediment, and plants is described in Section 6.8 of this RAWP. The HHRA also includes ingestion of animal products (such as beef and eggs). The uptake models used to estimate contaminant concentrations in animal products are highly uncertain. Conservative assumptions used to compensate for this uncertainty include the assumption that animals feed exclusively on contaminated plants and the use of conservative uptake factors, including some mass-limited uptake factors.

Land-Use Assumptions

Land use can change at any time; therefore, even defining current land use (i.e., during WTP operations) has some uncertainty associated with it, and defining future land use (i.e., after WTP shutdown) has even greater uncertainty. To compensate for this uncertainty, receptors are assumed to be present at the locations of maximum concentration regardless of actual land use at those locations and as determined by combining air model concentration and deposition rates according to Section 6.1. For example, a current residential scenario will be evaluated at the Hanford offsite location regardless of whether or not this location is presently in residential use or coincides with an air model grid point.

Selection of Representative Receptor Populations and Exposure Parameter Values

Every individual is unique, with different activity patterns (e.g., amount of time spent at home or work) and different physiologic characteristics (e.g., body weight). Therefore, modeling broad categories of receptors (e.g., resident) introduces uncertainty because (1) a limited number of general receptor categories are evaluated, and (2) exposure parameters are assigned within each receptor category to represent the activity patterns and physiologic characteristics of that receptor type. To compensate for this uncertainty, receptor types representing the highest potential for exposure are evaluated in the risk assessment, and these receptors are modeled using upper-bound assumptions to describe their activity patterns. For example, evaluation of a resident who is assumed to be at home 24 hours per day, 350 days per year at the point of maximum contaminant concentration will overestimate the risk to many other

receptor types not included in the quantitative risk assessment, such as a school child at the same location who may be at school 8 hours per day, 180 days per year.

While exposure assumptions used in the HHRA are designed to overestimate risk, some assumptions could underestimate the risk because of an individual having higher exposure than accounted for in the exposure assessment, or exposures via pathways (such as dermal) that have been identified by EPA in numerous risk assessments as being insignificant contributors to risk from thermal treatment facilities.

Makeup of the Waste, Formation of PICs and Modeling of Emissions

The Hanford tank waste is composed of several hundred organic and inorganic compounds including radionuclides. The tank chemistry is complex and varies from tank to tank. There are a number of technical challenges that complicate or interfere with getting a representative sample and analyzing that sample accurately. As such, there are uncertainties with assumed waste composition and properties. Likewise, the thermal processes within the WTP (e.g., the LAW and HLW melters and thermal catalytic oxidation unit) that produce products of incomplete combustion are complex reactions that are influenced by such variables as temperature, catalytic effects, organic precursors, and residence time. It is difficult to predict the types and concentrations of PICs produced by the varying feed streams that will be processed by the WTP. As such, the emissions modeling that has been performed in support of risk assessment carries uncertainties with regard to feed assumptions, PIC generation, in addition to equipment performance, and contaminant behavior. The use of conservative assumptions relating to these and other emissions related parameters are intended to overestimate the likely emissions from the WTP and compensate for the uncertainties with the feed and PIC formation mechanisms.

7.5.2 Uncertainty in Toxicity Assessment

Sources of uncertainty in the toxicity assessment include uncertainties surrounding the following:

- Toxicity values (*RfD*s and *RfC*s, *CSF*s and *URF*s)
- Cancer weight-of-evidence classifications
- Toxicity value data gaps
- Route-to-route extrapolations

Each of these sources of uncertainty in the toxicity assessment is described briefly below.

Toxicity Values

Because most of the toxicity values (*RfD*s and *RfC*s, *CSF*s and *URF*s) are based on laboratory exposures of animals, actual effects of environmental exposures to humans is unknown. Therefore, EPA-derived toxicity values are designed to provide an upper-bound estimate of risk (e.g., by incorporating numerous uncertainty factors). However, previous or concurrent exposures from sources other than the WTP are not considered in the EPA toxicity values for most chemicals. For example, all humans have been exposed to dioxins and PCBs and have some body burden associated with them. The additional exposures and their potential to increase body burdens of these chemicals due to the plant emissions are evaluated independent of existing risks, or as an incremental increase. It is not known how much such incremental exposures actually affect an individual's potential to suffer adverse effects from these exposures. This is regarded as a nonconservative uncertainty in the overall risk assessment.

Cancer Weight-Of-Evidence Classification

Uncertainty in the cancer weight-of-evidence classification will be considered in the HHRA by evaluating all Class A (human carcinogen), Class B (probable human carcinogen), and Class C (possible human carcinogen) chemicals as carcinogens.

Toxicity Value Data Gaps

The lack of toxicity data for some COPCs will contribute to an underestimation of risk if these chemicals are present in the emissions and are toxic to humans at the concentration emitted.

Route-To-Route Extrapolations

Uncertainties are associated with the estimation of dermal toxicity values from oral values. In addition, to address the toxicity value data gap issue, further assessment of constituent inhalation risk may be performed if oral toxicity values are available. If no *URF* or *RfC* are available, they can be derived from the CSF_{inh} or RfD_{inh} (respectively) using the conversion in WAC 173-340-708(7)b, which directs the risk assessor to take into account, where available, the respiratory deposition and absorption characteristics of the gases and inhaled particles.

7.5.3 Uncertainty in Risk Characterization

The risk characterization combines the results of the exposure assessment and toxicity assessment; therefore, all of the uncertainty in these two steps, as well as the steps prior to the exposure assessment (e.g., fate and transport modeling), contributes to the uncertainty in the risk characterization. Additional uncertainty in the risk characterization step surrounds the practice of summing cancer risks and noncancer hazard results across all chemicals and exposure pathways, regardless of the mode of action, as described below.

The assumption of strict additivity of chemical carcinogens that will be used in the SLRA assumes that (1) intakes of individual chemicals are small, and (2) there is no interaction among chemicals (i.e., no synergism or antagonism). The assumption of strict additivity of cancer risk from radionuclides is much less uncertain than for chemicals because the mode of action is the same for all radionuclides.

Multiple chemical exposures to noncarcinogens can result in synergism, antagonism, and/or additivity of biological responses when the chemicals act on similar target organs, or when the chemicals are metabolized by the same enzymatic pathways. The assumption of additivity will be used in the SLRA and is likely to overestimate the true human health hazards associated with exposure to the COPCs, since many chemicals may act on different target organs.

In addition to multiple chemicals, receptors may be exposed through more than one pathway. As the EPA (1989) notes:

> There are two steps required to determine whether risks or hazard indices for two or more pathways should be combined for a single exposed individual or group of individuals. The first is to identify reasonable exposure pathway combinations. The second is to examine whether it is likely that the same individuals would consistently face the "reasonable maximum exposure" for more than one pathway.

To maintain the conservative bias of the risk assessment, it is assumed that each receptor is exposed to all COPCs and ROPCs by all pathways.

7.5.4 Summary of Uncertainty

Human health risk assessment is a multi-step process and uncertainty is introduced at all steps of the process, including COPC and ROPC selection, estimating emission rates, environmental modeling, exposure assessment, toxicity assessment, and risk characterization. Whenever possible, conservative assumptions are used to compensate for uncertainties so that the final estimate of risk represents an overestimate, rather than an underestimate, of risk to actual receptor populations.

As described in Section 10 of this RAWP, an uncertainty assessment will be included in the SLRA to evaluate the contributors to, and potential impact of, uncertainty in the risk assessment. The purpose of the uncertainty assessment is to identify and discuss areas of uncertainty associated with the quantitative estimates of risk for the WTP. This discussion serves to place the risk estimates in proper perspective to allow fully informed risk management decisions.

7.6 Summary for Human Health Risk Assessment

Risks and hazards to human health from the potential emission of COPCs and ROPCs result from (1) exposure to the COPC or ROPC, and (2) the toxicity of the COPC or ROPC. The screening HHRA utilizes estimated emission rates (Section 5) and results of the fate and transport modeling (Section 6) to calculate potential human exposure to COPCs and ROPCs. This exposure information is combined with toxicity data to estimate the potential for adverse effects to human populations in the vicinity of the WTP.

The PRA will use conservative exposure assumptions to compensate for the high level of uncertainty associated with conducting a risk assessment for a facility that is still in the design phase. The PRA will include a qualitative uncertainty analysis.

The COPCs or ROPCs that exceed risk goals in the PRA will be revisited to determine whether unrealistic parameters were assigned to them in the PRA. If the analysis conducted in the PRA is considered reasonable, it may be necessary to alter operational characteristics of the WTP in order to reduce emissions to be within acceptable risk limits.

The FRA will include estimated emissions based on engineering calculations (e.g., PT Facility system emissions and vapor-phase organic emissions from WTP process cells) and environmental performance demonstration tests for the LAW and HLW vitrification systems. Based on the results of the environmental performance demonstration tests, the FRA may involve running new models, modeling additional chemicals, or changing model parameters. Information that will require updating in the FRA, as specified in the WTP DWP (WA7890008967), will include:

- Toxicity data current at the time of the submittal
- Compounds newly identified, or updated emissions data from current waste characterization and emission testing
- Air modeling updated to include stack gas parameters based on most current emissions testing and current WTP unit design
- Physical/transport properties of constituents current at the time of the submittal
- Process description based on current WTP unit design
- Emissions data and all supporting calculations based on current WTP unit design